Installation Instructions for the Community Satellite Processing Package (CSPP) / International MODIS/AIRS Processing Package (IMAPP) VIIRS and MODIS Reprojection Polar2grid Software

Beta Version 2.0

University of Wisconsin-Madison, Space Science and Engineering Center (SSEC)
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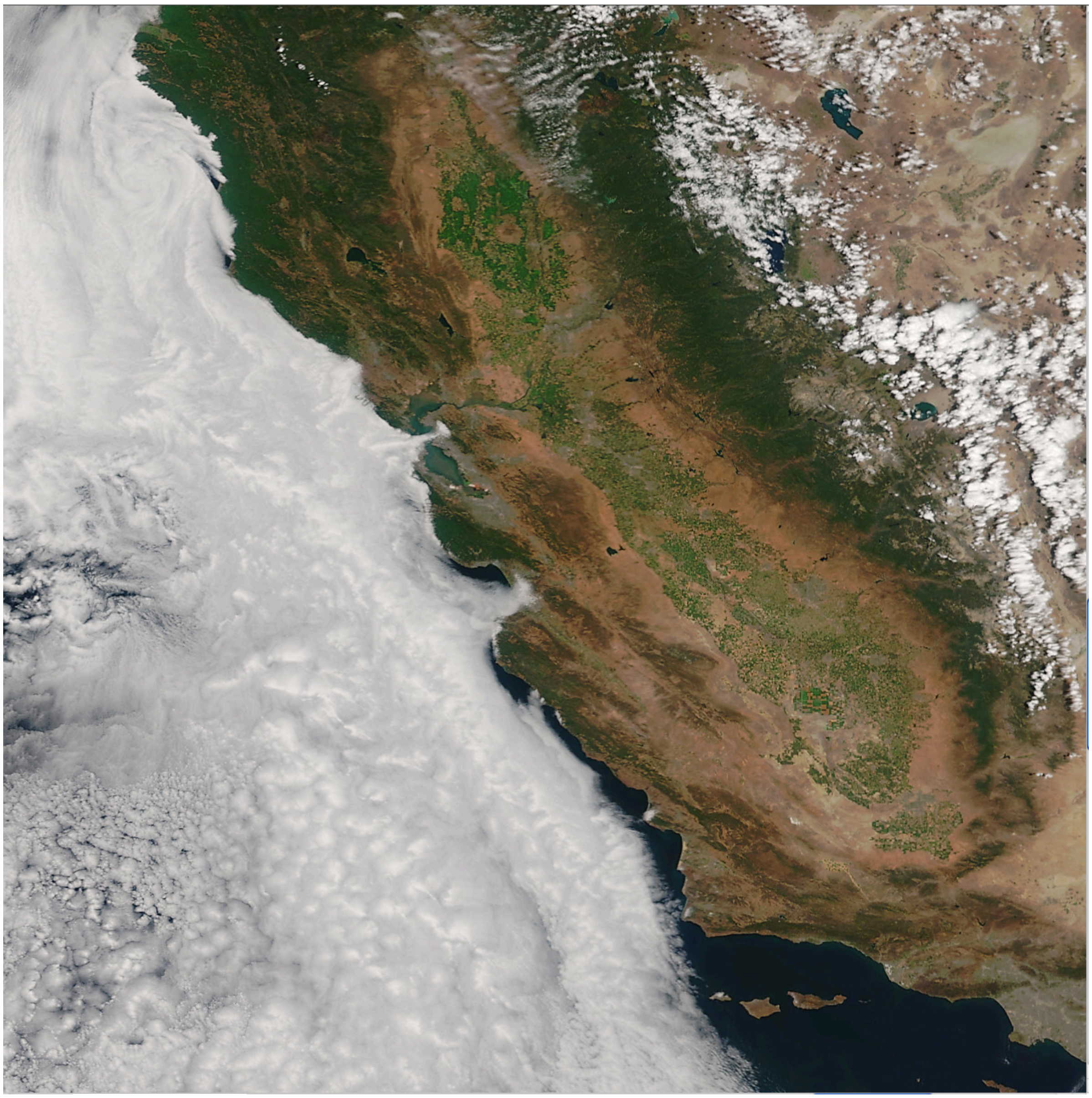

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Section 1: Introduction

1.1 Overview

This document contains instructions for installation and operation of the CSPP/IMAPP software package for extracting and remapping polar orbiting satellite VIIRS Sensor Data Records (SDRs), MODIS Level-1B (L1B) files and Advanced Very High Resolution Radiometer (AVHRR) data into output formats including an Advanced Weather Interactive Processing System (AWIPS I and II) compatible NetCDF 3 file, GeoTIFF and Keyhole Markup language Zipped (KMZ) file formats. The AWIPS system is the visualization and analysis tool used operationally in US National Weather Service Forecast Offices. GeoTIFF format is an image format for georeferenced raster imagery. Source code is included with this package. KMZ is a native Google Earth Geobrowser format.

The VIIRS SDRs contain calibrated and geolocated data arrays in HDF 5 format. MODIS L1B files contain calibrated and geolocated data arrays in HDF4 format. The supported AVHRR L1B files contain calibrated and geolocated data generated by the ATOVS and AVHRR Pre-processing Package (AAPP) (http://nwpsaf.eu/deliverables/aapp/) in binary format. These native data serve as the input for the Polar2grid software.

The CSPP/IMAPP Polar2grid v2.0 beta software is distributed through this temporary ftp site:

ftp://ftp.ssec.wisc.edu/pub/IMAPP/beta/p2g/ .

Software, test data, and documentation may be downloaded from this web site. Please use the 'Contact Us' form on the website to submit any questions or comments about CSPP.

More complete documentation for Polar2grid software is available through a website maintained by the Polar2Grid software engineer David Hoese at:
http://www.ssec.wisc.edu/software/polar2grid/ .

In addition, this open source software is also available through the Polar2grid github website,
http://github.com/davidh-ssec/polar2grid.

Some of the software used to perform the underlying reprojections is based on the MODIS Swath-to-Grid Toolbox (MS2GT) software modules, created by Terry Haran, University of Colorado. This software is freely distributed from: http://cires.colorado.edu/~tharan/ms2gt/.

1.2 Software Design

Polar2Grid has a modular design operating on the idea of satellite "products"; data observed by a satellite instrument. These products can be any type of raster data, such as temperatures, reflectances, radiances, or any other value that may be recorded by or calculated from an instrument. There are 4 main components of Polar2Grid used to work with these products: the Frontend, Backend, Compositor, and Remapper. Typically these components are "glued" together via bash shell execution scripts to create gridded versions of the user provided swath products.

1.3 What's new in version 2.0?

Polar2Grid Version 2.0 represents a significant revision of the original software. Because of the expansion of input and output products supported, execution is now more complex; commands that you may have used in previous versions may require modifications. Wherever possible, we have tried to maintain consistency of execution across all front and back end data sets.

A few of the Version 2.0 updates include:

- The Polar2Grid software has been expanded to provide support for AVHRR Level 1b from NOAA-18, NOAA-19, Metop-A and Metop-B satellites.
- KMZ, HDF5 and binary output formats can be created.
- MODIS corrected reflectance software execution is now included as part of true and false color image creation.
- Output file naming conventions have changed to reflect the vast number of data and products that are supported.
- MODIS L1B file naming conventions can be either IMAPP or NASA archive.
- A new dynamic VIIRS Day/Night Band enhancement option, provided by Dr. Curtis Seaman of the Cooperative Institute for Research in the Atmosphere (CIRA), is now available.
- MODIS and VIIRS 24 bit false color image creation is now supported.
- AWIPS-II grids have been modified and are now more accurate.

1.4 System requirements

System requirements for the Polar2grid software are as follows:

- Intel or AMD CPU with 64-bit instruction support,
- 8 GB RAM (minimum),
- CentOS 6 64-bit Linux (or other compatible 64-bit Linux distribution),
- 3 GB disk space (minimum).
- GLIBC version 2.7 or higher (execute "/lib64/libc.so.6" to find the version number)

Linux terminal commands included in these instructions assume the bash shell is used.

1.5 Polar2Grid Front Ends (Input Data)

1.5.1 VIIRS

VIIRS standard JPSS HDF5 format Sensor Data Records (SDRs) are required as input to the Polar2grid processing software for output file creation. The Polar2grid software can ingest VIIRS SDR files in HDF5 format from direct broadcast systems, or from the Suomi NPP archive at NOAA CLASS: http://www.class.ngdc.noaa.gov/. The inputs can be aggregated or granule based, but the files must be separated out into individual bands and geolocation files.

VIIRS Corrected Reflectance (CREFL) files are required as input to Polar2grid for the creation of 24 bit true color GeoTIFFs. These files are created as part of the crefl2gtiff.sh script, if they are not provided.

1.5.2 MODIS

MODIS standard Level1B HDF4 format files are required as input to the Polar2grid processing software for the creation of reprojected output files. The software has been tested on L1B data created by direct broadcast modisl1db software (http://seadas.gsfc.nasa.gov/modisl1db/), NASA archive files from LAADS (http://ladsweb.nascom.nasa.gov/) and NASA near-real-time LANCE input files (http://lance-modis.eosdis.nasa.gov/).

MODIS Corrected Reflectance (CREFL) files are required as input to Polar2grid for the creation of 24 bit true color GeoTIFFs. These files are created as part of the crefl2gtiff.sh script, if they are not provided.

1.5.3 AVHRR

The EUMETSAT Numerical Weather Prediction (NWP) Satellite Applications Facility (SAF) maintains and distributes the ATOVS and AVHRR Pre-processing Package (AAPP) software for direct broadcast. Polar2Grid supports the reprojection of AVHRR NOAA-18, NOAA-19 Metop-A and Metop-B satellite data in Standard AAPP L1B binary format. For a complete description of these binary files, please see the AAPP Documentation on Data Formats, available online at:

http://nwpsaf.eu/deliverables/aapp/NWPSAF-MF-UD-003_Formats.pdf

1.6 Disclaimer

Original scripts and automation included as part of this package are distributed under the GNU GENERAL PUBLIC LICENSE agreement version 3. Software 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 and/or IMAPP 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.

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Section 2: Installation and Configuration

2.1 Overview

The goal of Polar2Grid is to make extracting and reprojecting polar orbiter data easy and efficient. Execution takes place through simple bash shell scripts that execute python remapping and interpolation software. Standardized options exist for the shell script interfaces allowing users to point to files or directories containing files, and to define their own grids.

2.1 Installation of Polar2Grid Software

Download the following files from this Beta software ftp site:

ftp://ftp.ssec.wisc.edu/pub/IMAPP/beta/p2g/

```
CSPP_IMAPP_POLAR2GRID_V2.0_BETA.tar.gz
```

Next, unpack the tarfiles (a new directory named `polar2grid_v_2_0` will be created):

```
tar xf CSPP_IMAPP_POLAR2GRID_V2.0_BETA.tar.gz
```

Set the `POLAR2GRID_HOME` environment variable to the name of the directory where polar2grid was installed (`$HOME` in the example below), and then execute the environment script:

```
export POLAR2GRID_HOME=$HOME/polar2grid_v_2_0
source $POLAR2GRID_HOME/bin/polar2grid_env.sh
```

If you want to run the test case to verify your installation, download the following file:

```
CSPP_IMAPP_POLAR2GRID_V2.0_TEST_DATA.tar.gz
```

The test data should be unpacked in a directory separate from the polar2grid installation, e.g.,

```
cd $HOME
tar xf CSPP_IMAPP_POLAR2GRID_V2.0_TEST_DATA.tar.gz
```

This will create a `polar2grid_test` directory containing the test input, output and verification scripts for both MODIS and VIIRS.

Section 3: Polar2Grid Basics

Polar2Grid software is developed with modular components consisting of Frontends, Remappers, Compostitors, and Backends. These modules are executed using Python based software wrapped by simple shell bash scripts. Not all of the front ends are documented here. For full documentation on the capabilities of Polar2Grid, including more technical details, please see the Polar2Grid website that Dave Hoese has created at:

> http://www.ssec.wisc.edu/software/polar2grid/ .

This document focuses on 3 polar orbiter imager satellite instruments, Suomi-NPP VIIRS, Aqua and Terra MODIS, and NOAA-18, 19, Metop-A and Metop-B AVHRR. Inputs, outputs and backends supported are described in Table 1.

Each component is used in combination through the execution of Bourne Shell (bash) glue scripts. These simple execution interfaces make it easy to create high quality reprojections. The shell scripts are listed in the last column of Table 1.

Table 1: Polar2Grid supported satellites, instruments, output products and execution scripts used to create them.

Satellite, Instrument, Input Data, Source	Example input data filename	Output Product	Polar2Grid Bash Shell Script
Suomi-NPP VIIRS Sensor Data Records (CSPP or IDPS archive)	SVI01_npp_*.h5 GITCO_npp_*.h5	16 bit single band GeoTIFF	**viirs2gtiff.sh**
"	SVI01_npp_*.h5 GITCO_npp_*.h5	AWIPS NetCDF3	**viirs2awips.sh**
"	CREFLI_npp_*.hdf GITCO_npp_*.hdf	24 bit true and false color GeoTIFF	**crefl2gtiff.sh**
"	npp_viirs_i01*.tif viirs2gtiff.sh output .tif file	KML zipped file for Google Earth	**gtiff2kmz.sh**
"	SVI01_npp_*.h5 GITCO_npp_*.h5	HDF5	**viirs2hdf5.sh**
"	SVI01_npp_*.h5 GITCO_npp_*.h5	Binary	**viirs2binary.sh**
Aqua and Terra MODIS Level 1b (IMAPP or NASA archive files)	MOD021KM*.hdf MOD03*.hdf , or t1.*1000m.hdf t1.*.geo.hdf	16 bit single band GeoTIFF	**modis2gtiff.sh**
"	"	AWIPS NetCDF3	**modis2awips.sh**
"	a1.*.crefl.1000m.hdf a1.*.geo.hdf	24 bit true and false color GeoTIFF	**crefl2gtiff.sh**
"	aqua_modis_vis01*.tif modis2gtiff.sh output .tif file	KML zipped file for Google Earth	**gtiff2kmz.sh**
"	MOD021KM*.hdf MOD03*.hdf , or t1.*1000m.hdf t1.*.geo.hdf	HDF5	**modis2hdf5.sh**
"	"	Binary	**modis2binary.sh**
NOAA-18, NOAA-19, Metop-A and Metop-B AVHRR AAPP Level 1b	hrpt_noaa18_*.l1b	16 bit single band GeoTIFF	**avhrr2gtiff.sh**
"	"	AWIPS NetCDF3	**avhrr2awips.sh**
"	metopa_avhrr_band4*.tif avhrr2gtiff.sh output .tif file	KML zipped file for Google Earth	**gtiff2kmz.sh**
"	hrpt_noaa18_*.l1b	HDF5	**avhrr2hdf5.sh**

3.1.1 Standard Script Execution

Wherever possible, Polar2Grid execution scripts have been standardized, sharing many of the same required and optional arguments. The exception to this is the gtiff2kmz.sh script, which has a very simple interface, and designed to convert any polar2grid output GeoTIFF (*.tif) file into a Google Earth Geobrowser .kmz file. It is described in detail in Section 7.

Polar2Grid glue scripts follow this general pattern:

<bash script> <options> -f <path_to_files>/<list of files> ,

where <list of files> includes input calibrated data and geolocation files. If you provide only the <path_to_files>, the script will try to create as many products as it can from the files it finds in the directory. Temporary files and final output files are created in the current working directory.

For example, executing this script

```
viirs2gtiff.sh -f /home/data/viirs/sdr
```

will result in the creation of 8 bit GeoTIFF files of all VIIRS M-Band, I-Band and Day/Night Band SDR files it finds in the `/home/data/viirs/sdr` directory as long as the matching geolocation files are co-located. If there is more than one granule in the directory, the software will create an aggregate image of those bands. Since no grid was provided, the software will default to creating a ≈ 600m grid in Platte Carrée projection (Google Earth projection

The scripts operate by default in the current working directory, creating intermediate files as well as final output files there. Standard text output provides information on the progress of each script execution, including specific grid parameters, including,

grid_name
proj4_definition
cell_width
cell_height
grid width
grid height
origin_x
origin_y

This information is also included as part of a log file that is written for each script execution as well. The logfile provides very detailed execution information.

3.1.2 Standard Script Options

Aside from the required -f input argument, there are many standard optional arguments shared among the polar2grid execution scripts. A few are listed below.

`-h` Print detailed helpful information.
`--list-products` List all possible product options to use with `-p` from the given input data.
`-p` List of products to create.
`--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
`-g <grid_name>` Specify the output grid to use. Default is the Platte Carrée projection, also known as the wgs84 coordinate system. Predefined grid names are:

- **wgs84_fit – Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
- **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
- **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
- **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
- **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
- Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

`--debug` Don't remove intermediate files upon completion.
`-v` Print detailed log information.
`-h` Print detailed help information.
`--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

The remainder of this document provides detailed information on creating reprojections for each supported satellite imager, VIIRS, MODIS and AVHRR.

Section 4: Creating VIIRS Reprojections

4.1 Creating VIIRS SDR Single Band GeoTIFF files

The principal VIIRS GeoTIFF processing script is `$POLAR2GRID_HOME/bin/viirs2gtiff.sh`, which operates by default in the current directory. It creates intermediate files as well as final GeoTIFF (*.tif) output files. It is recommended that all files be removed from the work directory before each new execution of the script. To execute the GeoTIFF processing script, you must provide the path and name of the VIIRS SDR file or files, including the geolocation files. The standard execution is:

```
viirs2gtiff.sh -p <band shortname> -f /path_to_VIIRS_SDRs
```

where the `<band shortname>` is either i<band numer>, m<band number>, dnb (day/night band). For example,

```
viirs2gtiff.sh -p i04 i05 m12 m15 m16 -f /home/data/viirs/sdr
```

will result in the creation of standard projection VIIRS I-Bands 4 and 5, and M-Bands 12, 15 and 16. The geolocation files (GITCO and GMTCO) for the I- and M-Bands must also be located in the same directories as the calibrated data files. In this example, we also provided just the path to the directory containing the input data files. If more than one granule for a given band is found, it will create an aggregated image.

Other ways of choosing a subset of bands can be used as well. For instance,

```
viirs2gtiff.sh -f
SVI01_npp_d20130118_t2033237_e2034479_b00001_c20130118204802620622_cspp_dev.h5
GITCO_npp_d20130118_t2033237_e2034479_b00001_c20130118204805839283_cspp_dev.h5
```

This command will create a single GeoTIFF output file using the VIIRS SDR file SVI Band 1 granule from 18 January 2013 beginning at 20:33:23 UTC.

```
viirs2gtiff.sh -f SVM{01,02,12,15}*t18[1,2,3]*.h5 GMTCO*t18[1,2,3]*.h5
```

This implementation would create GeoTIFF files for only the VIIRS M bands 01, 02, 12 and 15 between the time range 18:10:00Z - 18:39:59Z.

For a complete listing of all possible band options, use the `--list-files command`,

```
viirs2gtiff.sh --list-products -f /path/to/your/files
```

You can also create a GeoTIFF file over a region that you define by using the `--grid-configs` option coupled with the `-g` option. **Appendix 1** describes how to define and create your own grids.

Several other options are available for `viirs2gtiff.sh`. A few are shown below. For a complete list, use `viirs2gtiff.sh -h` .

`viirs2gtiff.sh`

- `-g <grid_name>` Specify the output grid to use. Default is the Platte Carrée projection, also known as the wgs84 coordinate system. – For more details, see:
  http://www.ssec.wisc.edu/software/polar2grid/grids.html
  Predefined grid names:
  - **wgs84_fit** – **Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

- `--rescale-config <rescale configuration>` Specify the rescaling configuration to be used. Default depends upon data type. For more information, see: http://www.ssec.wisc.edu/software/polar2grid/rescaling.html .
- `-f <data_files>` Path and list of files to use. (**Required**)
- `--i-bands` Create images of all VIIRS I-Bands.
- `--m-bands` Create image of all VIIRS M-Bands.
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.

- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

For example:

```
viirs2gtiff.sh -g polar_north_pacific --debug -f ${HOME}/viirs/{SV,G}DNB*.h5
```

will create a GeoTIFF using a polar stereographic projection of all the VIIRS Day/Night Band .h5 files (SVNDNB) found in the ${HOME}/viirs directory and leave all intermediate files in the working directory upon completion.

4.1.1 VIIRS SDR GeoTIFF Output File Naming Convention

Upon successful execution of `viirs2gtiff.sh`, one or more output files are produced, using this general standard naming convention,

npp_viirs_<res><band>_YYYYMMDD_HHMMSS_<projection>.tif
Example: npp_viirs_m12_20150728_174748_wgs84_fit.tif

Where,
res is the VIIRS band resolution type – either m or i (for M-Band or I-Band).
band is the VIIRS instrument band number or dnb,
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second,
projection is the grid being projected to.

The only exception to this is the Day/Night band GeotTIFF files, which also include the type of scaling that was implemented. Please see Appendix 1 for a detailed description of the different DNB band enhancement options.

4.2 Creating VIIRS True Color and False Color GeoTIFF Files

The polar2grid software can create reprojected true color and false color 24 bit GeoTIFF files from input VIIRS corrected reflectance (CREFL) HDF4 input files and VIIRS Geolocation files (Terrain Corrected (GITCO* and GMTCO* or non-Terrain Corrected (GMODO* and GIMGO*)).

Polar2grid software creates and combines single band CREFL VIIRS Red (M-Band 5), Green (M-Band 4) and Blue (M-Band 3) wavelength data to create true color images. If the I-Band 1 data is also present in a CREFL file, then it will be used to spatially sharpen the image. The software performs a simple atmospheric Rayleigh scattering correction but with no adjustment for aerosol scattering (smoke and aerosols are still visible). The CREFL software is distributed by NASA's Direct Readout Lab, http://directreadout.sci.gsfc.nasa.gov/. This software is included as part of the Polar2Grid distribution.

In addition, the software can also easily create a false color Red/Green/Blue 24 bit GeoTIFF using Red:VIIRS M-Band 11 (2.25 μm), Green:VIIRS M-Band 7 (.87 μm) and Blue:VIIRS M-Band 5 (.67 μm). If the I-Band 1 data is also present in a CREFL file, then it will be used to spatially sharpen the image. This band combination is very effective at distinguishing land/water boundaries as well as burn scars.

4.2.1 VIIRS Polar2grid True Color and False Color GeoTIFF Driver Script

The principal GeoTIFF processing script is `$POLAR2GRID_HOME/bin/crefl2gtiff.sh`, which operates by default in the current directory. It creates intermediate files as well as final GeoTIFF (*.tif) output files. It is recommended that all files be removed from the work directory before each new execution of the script. The software can be used to create the CREFL files as part of the execution, or use previously created CREFL files to produce the final true/false color image. To execute the true color GeoTIFF processing script, you must provide the path and name of the input SDR or CREFL file or files, or the path and directory name containing a time sequential set of SDR or CREFL files. In each case, the VIIRS geolocation files must also be located in the same SDR or CREFL data directory. The CREFL files themselves do not contain geolocation arrays.

The VIIRS CREFL files use this native file naming convention:

M-Band Resolution Files:
CREFLM_npp_dYYYYMMDD_tHHMMSSS_eYYMMSSS.hdf
Ex: CREFLM_npp_ d20130611_t2035289_e2036531.hdf

I-Band Resolution Files:
CREFLI_npp_dYYYYMMDD_tHHMMSSS_eYYMMSSS.hdf
Ex: CREFLI_npp_d20130611_t2035289_e2036531.hdf

The date, begin and end times are the same as the input SDR granule files that are used to produce them.

Executing the `crefl2gtiff.sh` command will include the creation of the CREFL HDF4 files as part of the true color GeoTIFF image processing chain if the files do not already exist. Once the CREFL files have been created, more true color images can be generated from the same VIIRS dataset by providing the path and names of the CREFL files, and the path and name of the geolocation files as input to crefl2gtiff.sh.

For example, if you execute the following command from `${HOME}/crefl_work1`:

```
crefl2gtiff.sh -f /data2/viirs/sdr/SV*.h5 /data2/viirs/sdr/G{M,I}TCO*.h5
```

it will create I and M-Band CREFL HDF4 files for each input VIIRS SDR granule in the data set, and use those CREFL files to create output GeoTIFF files in the default Platte Carrée projection. Both GeoTIFF output files and the CREFL files will be left in the work directory (${HOME}/crefl_work1). I can create more output true color images from this VIIRS data segment by executing a command in a different work directory, such as:

```
cd ${HOME}/crefl_work2
crefl2gtiff.sh -g wgs84_fit_250  -f ${HOME}/crefl_work1/CREFL*.hdf
/data2/viirs/sdr/G{M,I}TCO*.h5
```

This command will use the CREFL files found in the `${HOME}/crefl_work1` directory and the matching terrain corrected geolocation files found in the `/data2/viirs/sdr/` directory to create a 250m true color GeoTIFF output file in Platte Carrée projection.

The following table shows the relationship of the band numbering scheme used in the CREFL HDF4 files to the VIIRS spectral bands.

Table 1: Corrected Reflectance (CREFL) File Band Names to VIIRS band mapping.

CREFL Band Number – CREFL File Prefix	VIIRS Band Number - Central Wavelength
CorrRefl_01 - CREFLM	M-Band 5 - .67 µm
CorrRefl_02 - CREFLM	M-Band 7 - .87 µm
CorrRefl_03 - CREFLM	M-Band 3 - .49 µm
CorrRefl_04 - CREFLM	M-Band 4 - .55 µm
CorrRefl_05 - CREFLM	M-Band 8 - 1.24 µm
CorrRefl_06 - CREFLM	M-Band 10 - 1.61 µm
CorrRefl_07 - CREFLM	M-Band 11 - 2.25 µm
CorrRefl_08 - CREFLI	I-Band 1 - .64 µm
CorrRefl_09 - CREFLI	I-Band 2 - .86 µm
CorrRefl_10 - CREFLI	I-Band 3 - 1.61 µm

More examples:

Executing a command like this,

```
crefl2gtiff.sh -f /viirs/CREFLM_npp_d20130605_t1727*.hdf /viirs/GMTCO*.h5
```

will create a set of VIIRS Red, Green and Blue CREFL GeoTIFF output files along with a 24 bit true color geotiff file for the granule from 5 June 2013 beginning at 17:27 UTC. The matching terrain corrected (GMTCO* and GITCO*), or non-terrain corrected (GMODO* and GIMGO*) files must also be identified. It will use the terrain corrected files if both are present. The output true color GeoTIFF will not be sharpened by the I-Band 01 data. However, by using this command:

```
crefl2gtiff.sh -f /viirs/CREFL[I,M]_npp_d20130605_t1727*.hdf /viirs/G{M,I}TCO*.h5
```

the output true color image will be sharpened, because it points to both the M and I-Band CREFL granule files. The output files created from this example are:

npp_viirs_viirs_crefl01_20130605_172727_wgs84_fit.tif - VIIRS M-Band 5 (Red)
npp_viirs_viirs_crefl03_20130605_172727_wgs84_fit.tif - VIIRS M-Band 4 (Green)
npp_viirs_viirs_crefl04_20130605_172727_wgs84_fit.tif - VIIRS M-Band 3 (Blue)
npp_viirs_viirs_crefl08_20130605_172727_wgs84_fit.tif - VIIRS I-Band 1 (used for image sharpening)
npp_viirs_true_color_20130605_172727_wgs84_fit.tif (24 bit true color)

The output file naming conventions include band numbers (01, 03, 04 and 08) that correspond to the band numbering conventions used in the CREFL HDF4 files.

You can also execute the processing script by providing the path containing VIIRS SDR files, e.g.,

```
crefl2gtiff.sh -f /data/npp/viirs/sdr
```

This command will create a set of corrected reflectance HDF4 files, and true color GeoTIFF files for all of the VIIRS SDR granule files in the directory. If more than one granule for a given band is found, it will create an aggregated set of images.

You can also create a GeoTIFF file over a region that you define by using the `--grid-configs` option coupled with the `-g` option. **Appendix 1** describes how to define and create your own grids.

There are many other options available for `crefl2gtiff.sh`. A few are shown below. For a complete list, `crefl2gtiff.sh -h` .

`crefl2gtiff.sh`

- `-g <grid_name>` Specify the output grid to use. Default is the Platte Carrée projection, also known as the wgs84 coordinate system. – For more details, see:
  http://www.ssec.wisc.edu/software/polar2grid/grids.html
  Predefined grid names:
  - **wgs84_fit** – **Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

- `-f <data_files>` Path and list of files to use (VIIRS SDR .h5 or CREFL .hdf) (**Required**)
- `--true-color` Create true color GeoTIFF (**Default**).
- `false_color --false-color` Create false color Red:(M-Band 11), Green:(M-Band 7) and Blue:(M-Band 5) 24 bit true color image.
- `--list-products` List all possible product options to use with `-p` (CREFL hdf files only).
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%**.
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.
- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

As an example, if I wanted to create both true and false color 24 bit images from a VIIRS pass of data that includes both SVI, SVM and geolocation h5 files, I could execute this command,

```
crefl2gtiff.sh  false_color --false-color --true-color -f
../data/test_data/rgb/viirs/input/*_npp_*.h5
```

If I want to list out all of the CREFL bands I can create GeoTIFFs from, I can use this command, pointing to the directory where the CREFL HDF4 files and VIIR geolocation filesare located,

```
crefl2gtiff.sh --list-products -f ../run/*.hdf
../data/test_data/rgb/viirs/input/*_npp_*.h5
```

which lists out these options,

```
viirs_crefl01
viirs_crefl02
viirs_crefl06
viirs_crefl04
viirs_crefl05
viirs_crefl06
viirs_crefl07
viirs_crefl08
viirs_crefl09
viirs_crefl10
```

If I wanted to create corrected reflectance GeoTIFF files from a subset of CREFL bands, I can use a command like this,

```
crefl2gtiff.sh -p viirs_crefl06 viirs_crefl03 -f ../run/*.hdf
../data/test_data/rgb/viirs/input/GMTCO*.h5
```

Executing this command produces two corrected reflectance GeoTIFF files of VIIRS M-Band 10 (1.61 µm) and VIIRS M-Band 3 (.49 µm) (See mapping of CREFL to VIIRS bands in Table 1). Note, that the command includes the path to the input VIIRS Geolocation files that match the date/time of the CREFL files since these files do not include latitude or longitude information.

4.2.2 VIIRS True Color and False Color Output File Naming Conventions

Upon successful execution of `crefl2gtiff.sh`, one or more output files are produced, using this general standard naming convention,

npp_viirs_<imagetype>_YYYYMMDD_HHMMSS_<reprojection>.tif
Examples: npp_viirs_true_color_20150707_040439_wgs84_fit.tif
npp_viirs_false_color_20150707_040439_wgs84_fit.tif
npp_viirs_viirs_crefl02_20150424_190954_wgs84_fit.tif

Where,
Imagetype is the product type (true_color, false_color, crefl<band>),
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second,
projection is the grid being projected to.

4.3 Creating VIIRS AWIPS Compliant NetCDF3 Files

The principal VIIRS AWIPS processing script is `$POLAR2GRID_HOME/bin/viirs2awips.sh`, which operates by default in the current directory. It creates intermediate files as well as final NetCDF-3 output files of byte values scaled from 0-255 using a standardized set of output filenames. Please note, these file naming conventions have changed from previous releases. The software will create AWIPS-II files for as many bands as requested by the user; the default is to produce as many bands as possible, dependent upon the input data.

The implementation of Polar2Grid to create AWIPS-II compatible files is very similar to that for GeoTIFFs as described in section 4.1. To execute the AWIPS processing script, you must provide the path and name of the VIIRS SDR file or files, including the geolocation files, e.g.

```
viirs2awips.sh -f
SVI01_npp_d20130118_t2033237_e2034479_b00001_c20130118204802620622_cspp_dev.h5
GITCO_npp_d20130118_t2033237_e2034479_b00001_c20130118204904620622_cspp_dev.h5
```

This command will create a NetCDF-3 output file using the VIIRS SDR SVI Band 1 granule file from 18 January 2013 beginning at 20:33:23 UTC, and the accompanying geolocation file (GITCO*.h5), for each AWIPS grid that the data set covered. There are currently 4 AWIPS grids that are supported by `viirs2awips.sh`:

- Grid 211e – East Contiguous US Grid at 1km resolution
- Grid 211w – West Contiguous US Grid at 1km resolution
- Grid 203 – Alaska Grid at 1km resolution
- Grid 204 – Pacific Grid (Hawaii) at 1km resolution

For more information on these AWIPS grid definitions, please see:
http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html

```
viirs2awips.sh -g 211e -f SVI{01,04}*t18[1,2,3]*.h5 GITCO*t18[1,2,3]*.h5
```

This implementation would create AWIPS files for only the VIIRS I-Bands 01 and 04 between the time range 18:10:00Z - 18:39:59Z, for the East Contiguous United States grid, also known as the 211e 1km grid.

You can also execute the processing script by providing just the path containing VIIRS SDR files, e.g.,

```
viirs2awips.sh -f /data/npp/viirs/sdr
```

This command will create all VIIRS SDR band AWIPS NetCDF files (if all bands are available) in the `/data/npp/viirs/sdr` directory, as long as the matching geolocation files are also found, covering all of the AWIPS grids that are touched by the latitutde/longitude boundaries of the aggregated granules.

Several options allow for selecting a subset of bands to reproject. The `--list-products` command provides a comprehensive list of all options available to `viirs2awips.sh` from the provided input data. You can then select from these options in the command line using `-p`. For example, typing this command,

```
viirs2awips.sh --list-products -f /data/npp/viirs/sdr
```

will output the short names all of the different output product reprojections that can be made. Among those listed are each individual I-Band and M-Band, and Day/Night band,

dnb
i01
i02
i03

…..
m01
m02
m03
m04
m05
m06
…

You can then choose a subset from this list, by executing a command like this one,

```
viirs2awips.sh -p i01 m06 m12 dnb -g 203 -f /data/npp/viirs/sdr
```

which will create individual AWIPS gridded NetCDF3 output files for bands SVI01, SVM06, SVM12 and the Day/Night band, covering the Alaska 203 grid. Again, the matching geolocation files must also be found in the same directory.

Many other options are available for `viirs2awips.sh`. A few are shown below. For a complete list of options, use `viirs2awips.sh -h` .

`viirs2awips.sh`

- `-g <grid_name>` Grid names:
    - 211e – East Contiguous US Grid at 1km resolution.
    - 211w – West Contiguous US Grid at 1km resolution.
    - 203 – Alaska Grid at 1km resolution.
    - 204 – Pacific Grid (Hawaii) at 1km resolution.
- `--rescale-config <rescale configuration>` Specify the rescaling configuration to be used. Default depends upon data type. For more information, see: http://www.ssec.wisc.edu/software/polar2grid/rescaling.html .
- `-f <data_files>` Path and list of files to use. (**Required**)
- `--i-bands` Create AWIPS files for all VIIRS I-Bands.
- `--m-bands` Create AWIPS files for all VIIRS M-Bands.
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%**.
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.

For example:

```
viirs2awips.sh -g 204 --debug -f ${HOME}/viirs/SVDNB*.h5 ${HOME}/viirs/GDNBO*.h5
```

will create VIIRS AWIPS NetCDF 3 files on the Pacific 204 AWIPS 1km grid using all of the VIIRS Day/Night Band .h5 files (SVNDNB) found in the ${HOME}/viirs directory and leave all intermediate files in the working directory upon completion.

4.3.1 VIIRS AWIPS Output File Naming Conventions

Upon successful execution of `viirs2awips.sh`, one or more output files are produced, using this general standard naming convention,

SSEC_AWIPS_npp_viirs_<res><band>_<awipsgrid>_ YYYYMMDD_HHMMS>.nc
Example: SSEC_AWIPS_npp_viirs_i03_211w_20150707_192211.nc

Where,

res is the VIIRS band resolution type – either m or i (for M-Band or I-Band).
band is the VIIRS instrument band number or dnb,
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC, .
MM is the data pass start time minute,
SS is the data pass start time second,
awipsgrid is the output 1km AWIPS file grid number (211e, 211w, 203, 204).

An exception to this is the Day/Night band AWIPS files, which also include the type of scaling that was implemented. Please see Appendix 1 for a detailed description of the different DNB band enhancement options.

4.4 Creating VIIRS Reprojections in HDF5 format

Polar2Grid also has the capability to create reprojections and store them in Hierarchical Data Format version 5 (HDF5 or H5). The principal VIIRS H5 processing script is `$POLAR2GRID_HOME/bin/viirs2hdf5.sh`, which operates by default in the current directory. It creates intermediate files as well as final H5 output files. Each execution of `viirs2hdf5.sh` creates a single output file containing the VIIRS bands stored as arrays within the H5 file. Each band is represented as 32 bit floating point numbers. Any single reprojected grid cell that is not filled with data will be represented by NaNs (Not a Number) in the output H5 file. The default physical value stored for each band is dependent upon the band number, as show below.

- Reflectances for VIIRS visible bands (I-Bands 1-3, M-Bands 1-11),
- Brightness temperatures in degrees Kelvin for VIIRS infrared bands (I-Band 3,4, M-Bands 12-16),
- Radiances for the Day/Night Band in W/(cm^{2} * steradian).

If no bands are chosen, the default is to reproject and store as many bands as possible in the output H5 file depending on the input data.

As an example, executing this command,

```
viirs2hdf5.sh -p dnb i01 i05 m04 m15 m16 -f ../input
```

will create a single reprojected output H5 file containing VIIRS Day/Night band radiances, I-Band 1 and M-Band 4 reflectances and I-Band 5 and M-Band 15 and 16 Brightness Temperatures from the files found in the ../input directory. The data will be reprojected into the default Platte Carrée projection.

The output file also contains grid attribute information, including the proj4 definition, and the reprojected grid dimensions. You can use the HDF5 utility h5dump (http://www.hdfgroup.org/HDF5/doc/RM/Tools.html#Tools-Dump) to quickly browse through the file; the following shows attribute output from the first variable stored in the file (dnb), h5dump -A npp_viirs_20150707_192211.h5

```
HDF5 "npp_viirs_20150707_192211.h5" {
GROUP "/" {
  GROUP "wgs84_fit" {
    ATTRIBUTE "cell_height" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): -0.0057
      }
    }
    ATTRIBUTE "cell_width" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): 0.0057
      }
    }
    ATTRIBUTE "height" {
      DATATYPE  H5T_STD_I64LE
      DATASPACE  SCALAR
      DATA {
      (0): 8554
      }
    }
    ATTRIBUTE "origin_x" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): -133.009
      }
    }
    ATTRIBUTE "origin_y" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): 64.9147
      }
    }
    ATTRIBUTE "proj4_definition" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "+proj=latlong +datum=WGS84 +ellps=WGS84 +no_defs"
      }
    }
    ATTRIBUTE "width" {
```

```
    DATATYPE  H5T_STD_I64LE
    DATASPACE  SCALAR
    DATA {
    (0): 9880
    }
  }
  DATASET "dnb" {
    DATATYPE  H5T_IEEE_F32LE
    DATASPACE  SIMPLE { ( 8554, 9880 ) / ( 8554, 9880 ) }
    ATTRIBUTE "begin_time" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "2015-07-07T19:22:11.629448"
      }
    }
    ATTRIBUTE "end_time" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "2015-07-07T19:34:57.421560"
      }
    }
    ATTRIBUTE "instrument" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "viirs"
      }
    }
    ATTRIBUTE "satellite" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
```

```
      DATA {
      (0): "npp"
      }
    }
  }
```

……………………………………..

Many other options are available for `viirs2hdf5.sh`. A few are shown below. For a complete list of options, use `viirs2hdf5.sh -h`.

`viirs2hdf5.sh`

- `-g <grid_name>` grid names:

  Predefined grid names:
  - **wgs84_fit – Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

- `-f <data_files>` Path and list of files to use. (**Required**)
- `--i-bands` Create reprojection for all VIIRS I-Bands.
- `--m-bands` Create reprojection for all VIIRS M-Bands.
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%**.
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.
- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

To use one of the predefined grids, I can execute a command like this,

```
viirs2hdf5.sh -g lcc_south_africa -f /viirs/SVM12*.h5 /viirs/GMTCO*.h5
```

which will reproject all VIIRS M-Band 12 granule files found in the /viirs directory into a Lambert Conic Conformal projection suitable for regions in and around Southern Africa, and store the reprojected brightness temperatures in Degrees Kelvin in the output HDF5 file as 32 bit floating point numbers.

4.4.1 VIIRS HDF5 Output File Naming Conventions

Upon successful execution of `viirs2hdf5.sh`, one or more output files are produced, using this general standard naming convention,

npp_viirs_YYYYMMDD_HHMMS.h5
Example: npp_viirs_20150707_192211.h5

Where,
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second.

4.5 Creating VIIRS Reprojections in Binary format

Polar2Grid also has the capability to create reprojections of VIIRS radiance, brightness temperature, reflectance and geolocation parameters and store them as individual arrays in flat binary format. The principal VIIRS binary processing script is `$POLAR2GRID_HOME/bin/viirs2binary.sh`, which operates by default in the current directory. It creates intermediate files as well as final binary output files. Each execution of `viirs2binary.sh` creates individual output files containing a single reprojected parameter. Each product is stored as 32 bit floating point numbers. Any single reprojected grid cell that is not filled with data will be represented by NaNs (Not a Number) in the output binary files. The default physical value stored for each band is dependent upon the band number, as show below.

- Reflectances for VIIRS visible bands (I-Bands 1-3, M-Bands 1-11),
- Brightness temperatures in degrees Kelvin for VIIRS infrared bands (I-Band 3,4, M-Bands 12-16),
- Radiances for the Day/Night Band in W/(cm^{2} * steradian).

If no bands are chosen, the default is to reproject and store as many bands as possible depending on the input data.

To see what products you can choose to reproject, use the `--list-products` optional argument, for example,

```
viirs2binary.sh --list-products -f polar2grid_test/viirs/input
```

Executing this command on the VIIRS test data set results in this output,

```
INFO     : Initializing swath extractor...
i01
i01_rad
i02
i02_rad
i04
i04_rad
i05
i05_rad
```

```
i_latitude
i_longitude
i_sat_azimuth_angle
i_sat_zenith_angle
i_solar_azimuth_angle
i_solar_zenith_angle
ifog
m03
m03_rad
m04
m04_rad
m05
m05_rad
m07
m07_rad
m11
m11_rad
m_latitude
m_longitude
m_sat_azimuth_angle
m_sat_zenith_angle
m_solar_azimuth_angle
m_solar_zenith_angle
```

The results show a subset of bands available, including visible reflectances (for example, i01, m03), radiances (for example, i02_rad, m11_rad) and brightness temperatures (for example, i04, i05), as well as geolocation and geometry parameters (for example, i_latitude, i_longitude, m_solar_zenith_angle). I can then choose parameters from the list to create the output files that I want.

As an example, I can execute this command to create binary output file reprojections of VIIRS visible I-Band 1 and I-Band 2 reflectances, VIIRS thermal infrared I-Band 4 and I-Band 5 brightness temperatures and I-Band latitude and longitude from our VIIRS test data set acquired on 6 June 2014.

```
viirs2binary.sh -p i01 i02 i04 i05 i_latitude i_longitude -f
polar2grid_test/viirs/input
```

As the output files are being created, the Polar2Grid standard text output will display the grid parameters including the width and height of the grid reprojection of your data set. In this case, we used the default Platte Carrée reprojection, which results in this grid information,

```
INFO    : Grid information:
        grid_name: wgs84_fit
        proj4_definition: +proj=latlong +datum=WGS84 +ellps=WGS84 +no_defs
        cell_width: 0.0057
        cell_height: -0.0057
        width: 6848
        height: 3449
        origin_x: -122.120094299
        origin_y: 47.2296714783
```

This information is also available in the output log file created with each script execution. The output consists of 6 binary files, one for each requested parameter.

```
npp_viirs_i01_20140617_194654_wgs84_fit.dat
npp_viirs_i02_20140617_194654_wgs84_fit.dat
npp_viirs_i04_20140617_194654_wgs84_fit.dat
npp_viirs_i05_20140617_194654_wgs84_fit.dat
npp_viirs_i_latitude_20140617_194654_wgs84_fit.dat
npp_viirs_i_longitude_20140617_194654_wgs84_fit.dat
```

Each file contains the parameters on the output grid stored as 32 bit floating point numbers. There is no header data in the file. Therefore, the output file size can be computed as, grid width * grid height * 4 bytes per cell. In our example, the file size for each parameter is then,

6484 * 3449 * 4 = 94475008 bytes.

Many other options are available for `viirs2binary.sh`. A few are shown below. For a complete list of options, use `viirs2binary.sh -h`.

`viirs2binary.sh`

- `-g <grid_name>` grid names:

  Predefined grid names:
  - **wgs84_fit – Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

- `-f <data_files>` Path and list of files to use. (**Required**)
- `--i-bands` Create reprojection for all VIIRS I-Bands.
- `--m-bands` Create reprojection for all VIIRS M-Bands.
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%**.
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.
- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

To use one of the predefined grids, I can execute a command like this,

```
viirs2binary.sh -g lcc_na -f polar2grid_test/viirs/input
```

which will reproject all VIIRS files found in the `polar2grid_test/viirs/input` directory into a Lambert Conic Conformal 1 km projection suitable for regions in and around North America, and store the reprojected data in individual product files as 32 bit floating point numbers.

4.5.1 VIIRS Binary Output File Naming Conventions

Upon successful execution of `viirs2binary.sh`, one or more output files are produced, using this general standard naming convention,

npp_viirs_<product>_YYYYMMDD_HHMMSS_<projection>.dat
Examples: npp_viirs_i01_20140617_194654_wgs84_fit.dat
npp_viirs_i05_20140617_194654_wgs84_fit.dat
npp_viirs_i_longitude_20140617_194654_wgs84_fit.dat

Where,
product is the VIIRS parameter name,
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second,
projection is the grid being projected to.

4.6 Running the VIIRS Polar2Grid Test Cases

4.6.1 Running the VIIRS Polar2grid GeoTIFF test case

To run the VIIRS GeoTIFF test case, unpack the test data as shown in Section 2.1 and then execute the commands below:

```
cd polar2grid_test/viirs
mkdir work
cd work
crefl2gtiff.sh false_color --false-color --true-color --grid-configs
${POLAR2GRID_HOME}/grid_configs/grid_example.conf -g colorado -f ../input
```

The test case consists of 3 input direct broadcast H5 SDR granules for a selection of VIIRS bands. In this test, the polar2grid software is using the example configuration file (`${POLAR2GRID_HOME}/grid_configs/grid_example.conf)` and the lambert conformal conic (lcc) “colorado” grid definition entry located within it. It will first create 3 CREFL I-Band and 3 CREFL M-Band files, and then use those to create a true color image at 300 m resolution, 750 lines x 1000 elements centered on the US state of Colorado. The processing should run in less than 1 minute and create 8 crefl output MODIS GeoTIFF files, including both true and false color output images, and the individual Corrected Reflectance images that went into producing the final products. If the VIIRS polar2grid processing script runs normally, it will return a status code equal to zero. If the VIIRS polar2grid processing script encounters a fatal error, it will return a non-zero status code.

To verify your output files against the output files created at UW/SSEC, execute the following commands:

```
cd ..
./p2g_compare_geotiff.sh output work
```

This script compares the values of all the GeoTiFF files for all VIIRS Bands. The output from our test system are shown below. If you see similar output, the test was successful.

```
./p2g_compare_geotiff.sh output work
Comparing work/npp_viirs_false_color_20140617_194654_colorado.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/npp_viirs_true_color_20140617_194654_colorado.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/npp_viirs_viirs_crefl01_20140617_194654_colorado.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/npp_viirs_viirs_crefl02_20140617_194654_colorado.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/npp_viirs_viirs_crefl03_20140617_194654_colorado.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/npp_viirs_viirs_crefl04_20140617_194654_colorado.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/npp_viirs_viirs_crefl07_20140617_194654_colorado.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/npp_viirs_viirs_crefl08_20140617_194654_colorado.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
All files passed
SUCCESS
```

Further image enhancement can be performed using the ImageMagick® "convert" utility, which is freely distributed from this website:

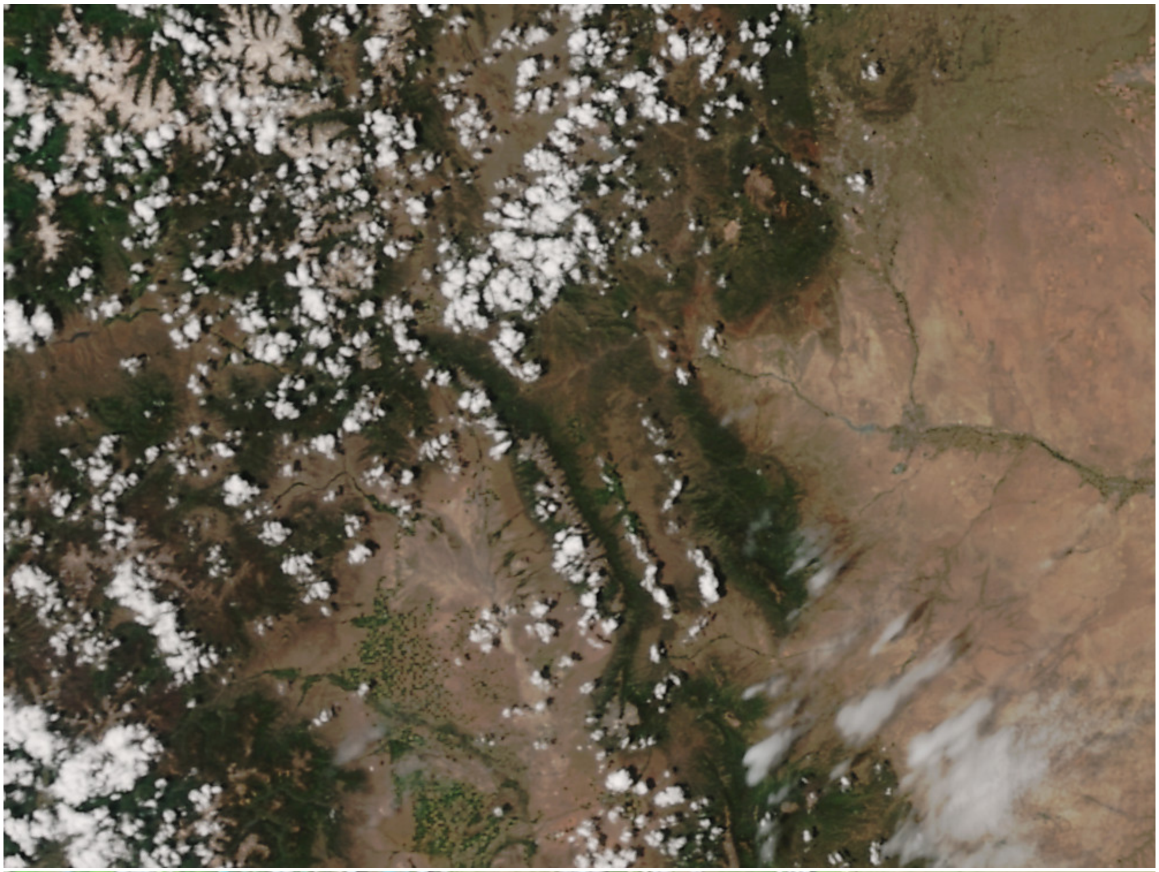
http://www.imagemagick.org/script/index.php

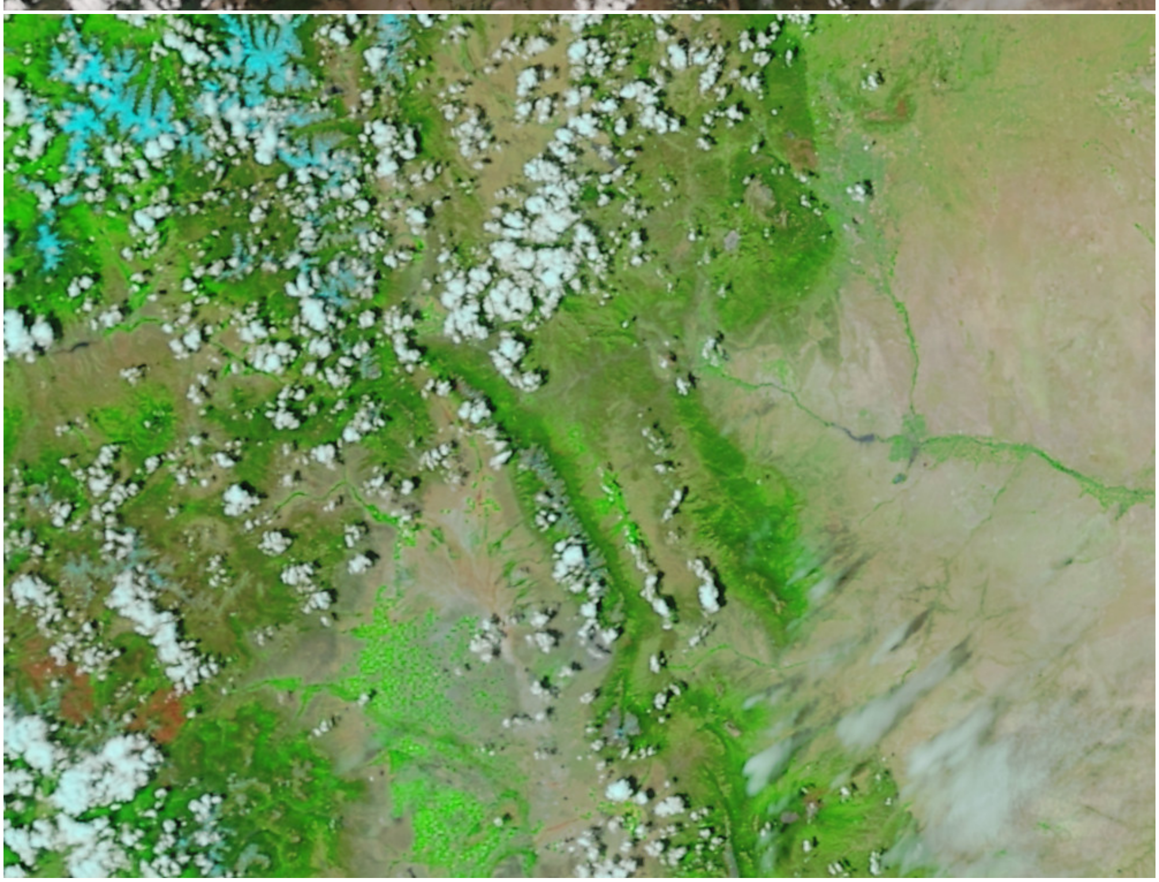
As an example, to sharpen and enhance our true and false color images and convert from .tif to .jpg format, you could use these commands:

```
convert -sigmoidal-contrast 3,50% -modulate 100,125,100 -gamma 1.1 -unsharp 0 -quality 90 \
npp_viirs_false_color_20140617_194654_colorado.tif \
npp_viirs_false_color_20140617_194654_colorado.jpg

convert -sigmoidal-contrast 3,50% -modulate 100,125,100 -gamma 1.1 -unsharp 0 -quality 90 \
npp_viirs_true_color_20140617_194654_colorado.tif \
npp_viirs_true_color_20140617_194654_colorado.jpg
```

The output VIIRS true color and false color GeoTIFF converted .jpg files, `npp_viirs_true_color_20140617_194654_colorado.jpg` and `npp_viirs_false_color_20140617_194654_colorado.jpg`, are shown below. These files are included in the polar2grid_test/viirs/output directory for comparison.





4.6.2 Running the VIIRS to AWIPS test case

To run the Polar2Grid VIIRS to AWIPS test case, unpack the test data as shown in Section 2.1 and then execute the commands below:

```
cd polar2grid_test/viirs
mkdir work_awips
cd work_awips
viirs2awips.sh -g 211w -f ../input/SVI{01,02,05}*.h5 ../input/GITCO*.h5
```

The test case consists of 3 input direct broadcast HDF 5 SDR granules from 17 June 2014 for a selection of VIIRS bands. The polar2grid software should run in less than 1 minute and create 3 output VIIRS NetCDF 3 files (I-Bands 1, 2 and 5) consisting of scaled integers ranging from 0 to 255 on the AWIPS West CONUS grid 211w. If the VIIRS polar2grid processing script runs normally, it will return a status code equal to zero. If the VIIRS polar2grid processing script encounters a fatal error, it will return a non-zero status code.

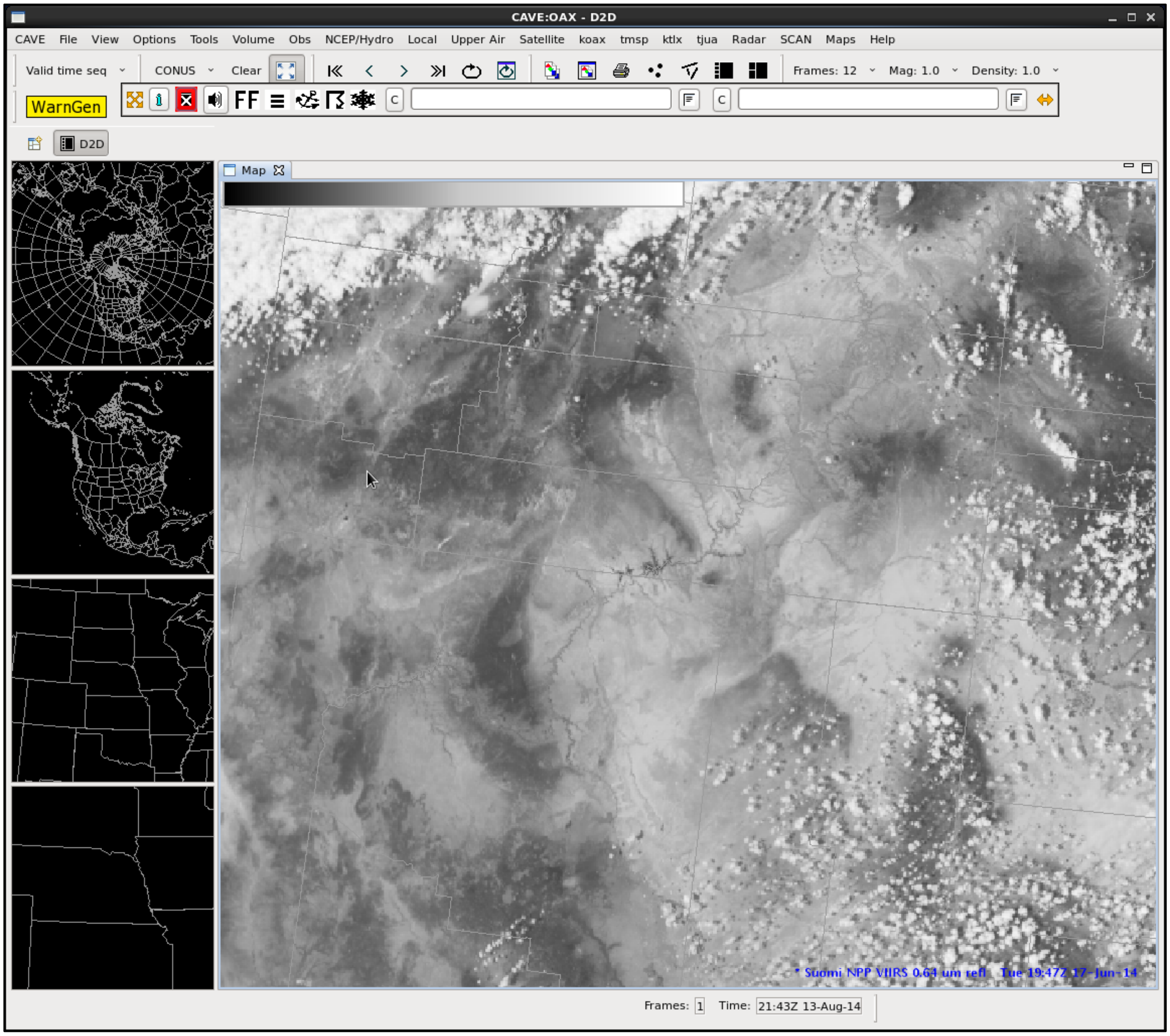
To verify your output files against the output files created at UW/SSEC, execute the following commands:

```
cd ..
./p2g_compare_netcdf.sh output work_awips
```

This script compares the values of all the NetCDF files for all of the VIIRS Bands. The output from our test system are shown below. If you see similar output, the test was successful.

```
./p2g_compare_netcdf.sh output work_awips
Comparing work/SSEC_AWIPS_npp_viirs_i01_211w_20140617_194654.nc to known valid file
SUCCESS: 0 pixels out of 22528000 pixels are different
Comparing work/SSEC_AWIPS_npp_viirs_i02_211w_20140617_194654.nc to known valid file
SUCCESS: 0 pixels out of 22528000 pixels are different
Comparing work/SSEC_AWIPS_npp_viirs_i05_211w_20140617_194654.nc to known valid file
SUCCESS: 0 pixels out of 22528000 pixels are different
All files passed
SUCCESS
```

A screen capture of the SVI01 AWIPS NetCDF file, SSEC_AWIPS_VIIRS-WCONUS_1KM_SVI01_20140617_1947.55779608, as displayed in AWIPS-II is shown below.



Section 5: Creating MODIS Reprojections

5.1 Creating MODIS Level 1B Single Band GeoTIFF files

The principal MODIS GeoTIFF processing script is `modis2gtiff.sh`, which operates by default in the current directory. It creates GeoTIFF (*.tif) output files for a select number of MODIS bandwidths (1-7, 20-36) using input Aqua and Terra 250m or 1km Level 1B files. More than one granule can be used; if more that one file is presented as input an aggregated image will be created. The geolocation file or files must be located in the same directory as the radiance/reflectance files. The input files can use either the International MODIS/AIRS Processing Package (IMAPP) or NASA archive naming conventions.

IMAPP naming conventions:

(a1 or t1).yyddd.hhmm.1000m.hdf 1km
(a1 or t1).yyddd.hhmm.250m.hdf 250m
(a1 or t1).yyddd.hhmm.geo.hdf geolocation

(Where a1-aqua, t1-terra, yy - year last 2 digits, ddd – day of the year, hh-hour, mm- minute)

NASA archive naming conventions:

(MOD021KM or MYD021KM).Ayyyyddd.hhmm.006.*.hdf 1km
(MOD02QKM or MYD02QKM).Ayyyyddd.hhmm.006.*.hdf 250m
(MOD03 or MYD03).Ayyyyddd.hhmm.006.*.hdf geolocation

(Where MYD-aqua, MOD-terra, yyyy – 4 digit year, ddd – day of the year, hh-hour, mm- minute)

MODIS L1B file	**MODIS Polar2grid Bands Supported for GeoTIFF file creation**
250m Ex: a1.13171.2033.250m.hdf or MYD02QKM.A2013171.2033.*.hdf	**Visible Reflectance Bands** 1 (.65 µm), 2 (.86 µm)
1 km Ex: a1.13171.2033.1000m.hdf or MYD021KM.A2013171.2033.*.hdf	**Visible Reflectance Bands** 1 (.65 µm), 2 (.86 µm), 3 (.47 µm), 4 (.55 µm), 5 (1.2 µm), 6 (1.6 µm), 7 (2.1 µm), 26 (1.38 µm) **Thermal Infrared Bands** 20 (3.75 µm), 21 (3.9 µm (fires)), 22 (3.9 µm), 23 (4.0 µm), 24 (4.4 µm), 25 (4.5 µm), 27 (6.7 µm), 28 (7.3 µm), 29 (8.5 µm), 30 (9.7 µm), 31 (11 µm), 32 (12.0µm), 33 (13.3 µm), 34 (13.6 µm), 35 (13.9 µm), 36 (14.2 µm)

It is recommended that all files be removed from the work directory before each new execution of the script. To execute the GeoTIFF processing script, you must provide the path and name of the MODIS L1B file, and geolocation file, for example,

```
modis2gtiff.sh -f /p2g/a1.13171.2033.250m.hdf  /p2g/a1.13171.2033.geo.hdf
```

This command will create two GeoTIFF output files (Band 1 and Band 2) using the Aqua MODIS 250m Level 1B input pass from 20 June 2013 beginning at 20:33 UTC, reprojecting the data onto the default Platte Carrée projection at .0057 degree resolution (600m at mid-latitudes).

The same command can also be executed using substitutions, like this,

```
modis2gtiff.sh -f /p2g/a1.13171.2033.{250m,geo}.hdf
```

The `-f` flag also allows a user to point to a directory containing Aqua or Terra MODIS data, for example,

```
modis2gtiff.sh -f /p2g
```

which will produce the same output files as the example above, if only the 250m and geolocation file are stored in the p2g directory.

Use the --list-products option to view all potential GeoTIFF products that can be created from the given input data, such as,

```
modis2gtiff.sh --list-products -f /modis/MYD021KM.A2015230.0415.006.*.hdf
/modis/MYD03.A2015230.0415.006.*.hdf
```

Once you have this list, you can use the -p option to choose a subset of the bands,

```
modis2gtiff.sh -p bt27 vis07 -f /modis/MYD0{2KM,3}.A2015230.0415.006.*.hdf
/modis/MYD03.A2015230.0415.006.*.hdf
```

Executing this command will create two reprojected GeoTIFF files of the Aqua MODIS Band 7 reflectances and Band 27 Brightness Temperatures in the default Platte Carrée projection.

Many other options are available for `modis2gtiff.sh`. A few are shown below. For a complete list of options, use `modis2gtiff.sh -h`.

`modis2gtiff.sh`

- `-g <grid_name>` Specify the output grid to use. Default is the Platte Carrée projection, also known as the wgs84 coordinate system. – For more details, see:
  http://www.ssec.wisc.edu/software/polar2grid/grids.html
  Predefined grid names:
  - **wgs84_fit – Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

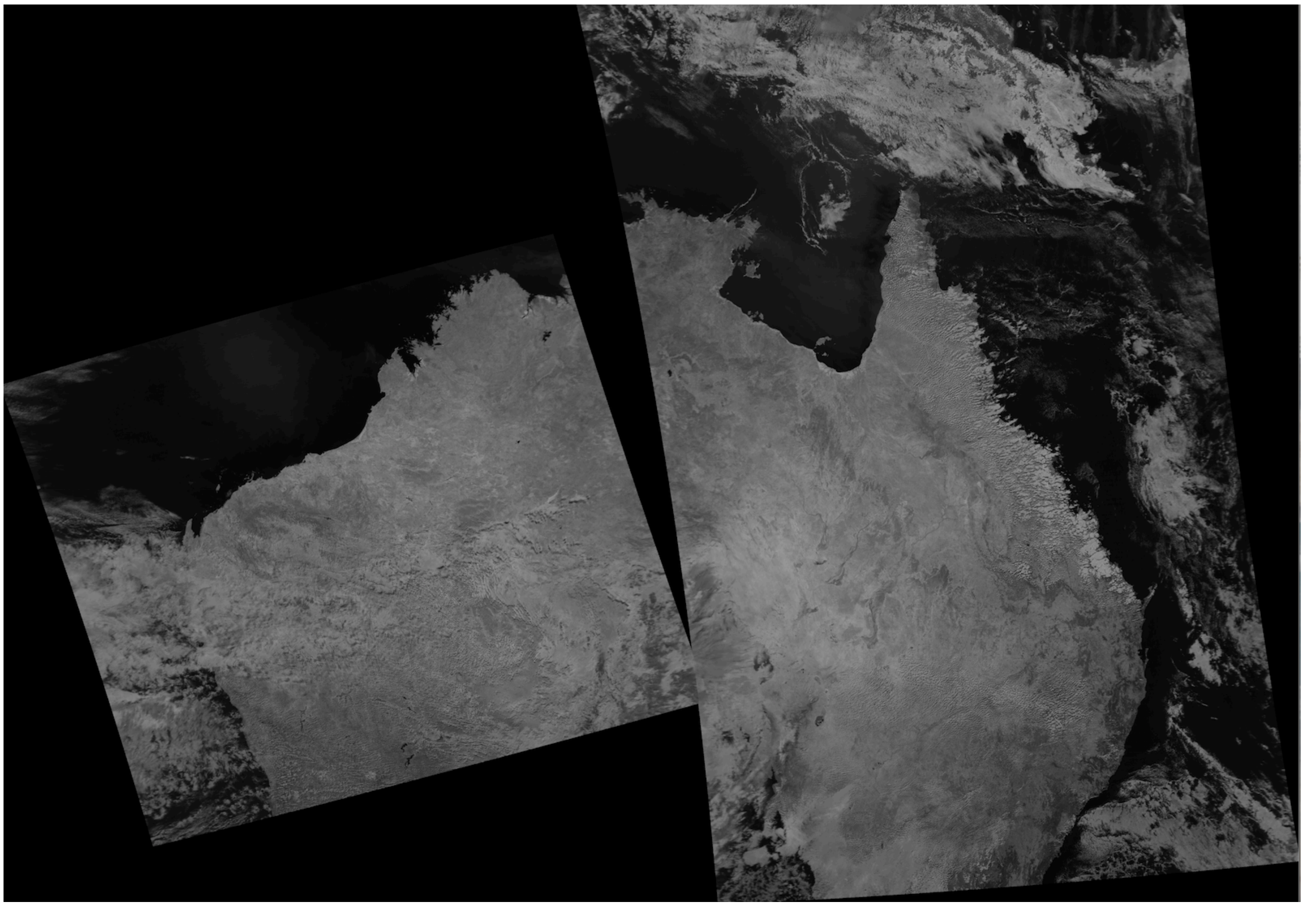
- `--rescale-config <rescale configuration>` Specify the rescaling configuration to be used. Default depends upon data type. For more information, see: http://www.ssec.wisc.edu/software/polar2grid/rescaling.html .
- `-f <data_files>` Path and list of files to use. (**Required**)
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--bt-products` Create brightness temperatures images of all MODIS Infrared Bands.
- `--vis-products` Create reflectance images of all MODIS Visible Bands.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.
- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

More examples

To create a 1 km Lambert Conic Conformal GeoTIFF reprojection over Australia of all visible bands available in a series of 1 km Aqua MODIS files from the same day, I could use a command like this one,

```
modis2gtiff.sh --vis-products -g lcc_aus -f /modis/MYD0{2KM,3}.A2015230..*.hdf
/modis/MYD03.A2015230.*.hdf
```

which would produce a total of 8 output visible reflectance image files (MODIS band 1-7 and band 26). An example of the aggregated image output file (aqua_modis_vis07_20150818_040500_lcc_aus.tif) appears below for Band 7 (2.1 μm) below. In this case I used three MODIS input granules from two separate Aqua MODIS passes for the reprojection.



5.1.1 MODIS Level 1B GeoTIFF Output File Naming Convention

Upon successful execution of `modis2gtiff.sh`, one or more output files are produced, using this general standard naming convention,

<sat>_modis_<cal><band>_YYYYMMDD_HHMMSS_<projection>.tif
Example: aqua_modis_vis01_20150818_040500_lcc_aus.tif

Where,

sat is the Polar Orbiter Satellite platform (either aqua or terra),
cal is the band calibration (bt, vis or rad for brightness temperature, reflectance or radiance),
band is the MODIS instrument band number,
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,

SS is the data pass start time second,
projection is the grid being projected to.

5.2 Creating MODIS True Color and False Color GeoTIFF Files

The polar2grid software can create reprojected true color and false color 24 bit GeoTIFF files from MODIS Corrected REFLectance (CREFL) HDF4 input files and Level 1B geolocation files. Polar2grid software creates and combines single band CREFL MODIS Red (MODIS Band 1), Green (MODIS Band 4) and Blue (MODIS Band 3) wavelength data to create true color images. It uses the MODIS 1km CREFL file to create a true color image, but if the 250m L1B CREFL file is available then it will be used to spatially sharpen the image to 250m. The CREFL software performs a simple atmospheric Rayleigh scattering correction but with no adjustment for aerosol scattering (smoke and aerosols are still visible). The CREFL software is distributed by NASA's Direct Readout Lab, http://directreadout.sci.gsfc.nasa.gov/. This software is included as part of the Polar2Grid distribution.

In addition, the software can also easily create a false color Red/Green/Blue 24 bit GeoTIFF using Red:MODIS Band 7 (2.21 µm), Green:MODIS Band 2 (.86 µm) and Blue:MODIS Band 1 (.65 µm). If the 250m L1B CREFL data is also present in a CREFL file, then it will be used to spatially sharpen the image. This band combination is very effective at distinguishing land/water boundaries as well as burn scars.

5.2.1 MODIS Polar2grid True Color and False Color GeoTIFF Driver Script

The principal GeoTIFF processing script is `$POLAR2GRID_HOME/bin/crefl2gtiff.sh`, which operates by default in the current directory. It creates intermediate files as well as final GeoTIFF (*.tif) output files. It is recommended that all files be removed from the work directory before each new execution of the script. The software can be used to create the CREFL files as part of the execution, or use previously created CREFL files to produce the final true color image. To execute the true color GeoTIFF processing script, you must provide the path and name of the input MODIS Level 1B or CREFL file or files, or the path and directory name containing one or more Level 1B and/or CREFL files. In each case, the MODIS geolocation files must either be located in the same SDR or CREFL data directory, or explicitly listed (including paths) as input. The CREFL files themselves do not contain geolocation arrays.

The MODIS CREFL files, use this native file naming convention:

(a1 or t1).yyddd.hhmm.crefl.1000m.hdf 1km
(a1 or t1).yyddd.hhmm.crefl.500m.hdf 500m
(a1 or t1).yyddd.hhmm.crefl.250m.hdf 250m
(Where a1-aqua, t1-terra, yy - year last 2 digits, ddd – day of year, hh-hour, mm- minute)

Example Filenames: t1.13171.2033.crefl.1000m.hdf, t1.13171.2033.crefl.250m.hdf

The date, and granule start times are the same as the input L1B granule files that are used to produce them.

Executing the `crefl2gtiff.sh` command will include the creation of the CREFL HDF4 files as part of the true color GeoTIFF image processing chain if the files do not already exist.

First, let's look at an example when using only the MODIS 1km and geolocation file as input,

```
crefl2gtiff.sh -f /modis/data/MOD0{21KM,3}.A2015230.0410.*.hdf
```

This command will first create a 1000m corrected reflectance file, (t1.15230.0410.crefl.1000m.hdf), and then use that file to produce MODIS Red, Green and Blue CREFL GeoTIFF files along with a 24 bit true color GeoTIFF file for the MODIS Terra granule from 18 August 2015 beginning at 04:10 UTC. The output true color GeoTIFF spatial resolution will not be sharpened by the 250m Band 1 data. You can ensure that it is sharpened, by also providing the 500m and 250m MODIS Level 1B files as input,

```
crefl2gtiff.sh -f /modis/data/M0D0{021KM,2HKM,2QKM,3}.A2015230.0410.*.hdf
```

The output true color image will be sharpened because the 500m and 250m files are explicitly included among the files to be used in this execution.

Once the CREFL files have been created, more 24 bit images can be generated from the same MODIS dataset by providing the path and names of the CREFL files, and the path and name of the geolocation files as input to crefl2gtiff.sh. For example, if you execute the following command from `${HOME}/crefl_work1`:

```
crefl2gtiff.sh -f /modis/CONUS/t1.15230.1906.{1000m,500m,250m,geo}.hdf
```

This command will create a set of MODIS Red, Green and Blue CREFL GeoTIFF files along with a 24 bit true color GeoTIFF file for the MODIS granule from 18 August 2015 beginning at 19:06 UTC. In this example, the IMAPP naming convention is used. The output true color GeoTIFF will be sharpened by the 250m Band 1 data because it is explicitly included among the files to be used in this execution.

The output CREFL HDF4 and GeoTIFF files created from this example are:

Output Corrected Reflectance Files
t1.15230.1906.crefl.1000m.hdf
t1.15230.1906.crefl.250m.hdf
t1.15230.1906.crefl.500m.hdf

Output GeoTIFF Files
terra_modis_modis_crefl01_1000m_20150818_190600_wgs84_fit.tif –- MODIS 1km Band 1 (Red)
terra_modis_modis_crefl03_1000m_20150818_190600_wgs84_fit.tif – MODIS 1km Band 3 (Blue)
terra_modis_modis_crefl04_1000m_20150818_190600_wgs84_fit.tif – MODIS 1km Band 4 (Green)
terra_modis_modis_crefl01_250m_20150818_190600_wgs84_fit.tif – MODIS 250m Band 1 (Used for sharpening)
terra_modis_true_color_20150818_190600_wgs84_fit.tif – Output 24 bit GeoTIFF file

Since no optional projection was provided, the output images use the default Platte Carrée projection. Both GeoTIFF output files and the CREFL files will be left in the work directory (${HOME}/crefl_work1). I can create more output true color images from this MODIS data segment by executing a command in a different work directory, such as:

```
cd ${HOME}/crefl_work2
crefl2gtiff.sh -g wgs84_fit_250  -f
${HOME}/crefl_work1/t1.15230.1906.crefl.*.hdf /modis/CONUS/t1.15230.1906.geo.hdf
```

This command will use the CREFL files found in the `${HOME}/crefl_work1` directory and the matching MODIS geolocation file found in the `/modis/CONUS` directory to create a 250m true color GeoTIFF output file in Platte Carrée projection.

You can also execute the processing script by providing the path containing MODIS L1B or corrected reflectance files, e.g.,

```
crefl2gtiff.sh -f /data/aqua/modis/crefl
```

This execution allows a user to point to a directory containing Aqua or Terra MODIS data, however, the directory must contain either MODIS L1B files, and/or Corrected Reflectance files and matching geolocation files.

You can also create a GeoTIFF file over a region that you define by using the `--grid-configs` option coupled with the `-g` option. **Appendix 1** describes how to define and create your own grids.

There are many other options available for `crefl2gtiff.sh`. A few are shown below. For a complete list, use `crefl2gtiff.sh` **-h** .

`crefl2gtiff.sh`

- `-g <grid_name>` Specify the output grid to use. Default is the Platte Carrée projection, also known as the wgs84 coordinate system. – For more details, see:
  http://www.ssec.wisc.edu/software/polar2grid/grids.html
  Predefined grid names:
  - **wgs84_fit** – **Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

- `-f <data_files>` Path and list of files to use (MODIS L1B or CREFL *.hdf) (**Required**)
- `--true-color` Create true color GeoTIFF (**Default**).
- `false_color --false-color` Create false color Red:(MODIS Band 7),
  Green:(MODIS Band 2) and Blue:(MODIS Band 1) 24 bit true color image.
- `--list-products` List all possible product options to use with `-p` (CREFL hdf files only).
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%**.
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.
- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

More examples

If you want to create both true and false color 24 bit GeoTIFF images from a MODIS set of input L1B files located in the `/modis/aqua` directory, you can execute a command like this one,

```
crefl2gtiff.sh  false_color --false-color --true-color -f /modis/aqua
```

This command will first create the corrected reflectance files, and use those to generate the true and false color GeoTIFF files. If you want to list out all of the CREFL bands I can create GeoTIFFs from, I can use this command, pointing to the directory where the CREFL HDF4 files are located,

```
crefl2gtiff.sh --list-products -f *.hdf
```

Which lists these options,

```
modis_crefl01_1000m
modis_crefl01_250m
modis_crefl01_500m
modis_crefl02_1000m
modis_crefl02_250m
modis_crefl02_500m
modis_crefl03_1000m
modis_crefl03_250m
modis_crefl03_500m
modis_crefl04_1000m
modis_crefl04_250m
modis_crefl04_500m
modis_crefl05_1000m
modis_crefl05_500m
modis_crefl06_1000m
modis_crefl06_500m
modis_crefl07_1000m
modis_crefl07_500m
```

If I wanted to create corrected reflectance GeoTIFF files from a subset of CREFL bands, I can use a command like this,

```
crefl2gtiff.sh -p modis_crefl01_250m modis_crefl02_250m
-f /data/run/*.hdf  /modis/aqua/*geo.hdf
```

Executing this command produces two corrected reflectance GeoTIFF files; MODIS 250m Band 1 and MODIS 250m Band 2. Note, that the command includes the path to the input MODIS Geolocation file that match the date/time of the CREFL files since they do not include latitude or longitude information.

5.2.2 MODIS True Color and False Color Output File Naming Conventions

Upon successful execution of `crefl2gtiff.sh`, one or more output files are produced, using this general standard naming convention,

<sat>_modis_<imagetype>_"<crefl resolution>"_YYYYMMDD_HHMMSS_<projection>.tif

Examples: terra_modis_true_color_20150818_190600_wgs84_fit.tif
terra_modis_false_color_20150818_190600_wgs84_fit.tif
terra_modis_modis_crefl01_250m_20150818_190600_wgs84_fit.tif

Where,
sat is the Polar Orbiter Satellite platform (either aqua or terra),
imagetype is the product type (true_color, false_color, crefl<band>),
crefl resolution is the CREFL file resolution used,
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second,
projection is the grid being projected to.

5.3 Creating MODIS AWIPS Compliant NetCDF3 Files

Polar2Grid is also able to create AWIPS compliant files on National Weather Service (NWS) grids. The principal MODIS AWIPS processing script is `$POLAR2GRID_HOME/bin/modis2awips.sh`, which operates by default in the current directory. It creates intermediate files as well as final NetCDF-3 output files of byte values scaled from 0-255 using a standardized set of output filenames. Please note, these file naming conventions have changed from previous releases. It creates AWIPS output files for a select number of MODIS bandwidths (1-7, 20-36) using input Aqua and Terra 250m or 1km Level 1B files. The geolocation file or files must be located in the same directory as the radiance/reflectance files. The input files can use either the International MODIS/AIRS Processing Package (IMAPP) or NASA archive naming conventions.

IMAPP naming conventions:
(a1 or t1).yyddd.hhmm.1000m.hdf 1km
(a1 or t1).yyddd.hhmm.250m.hdf 250m
(a1 or t1).yyddd.hhmm.geo.hdf geolocation
(Where a1-aqua, t1-terra, yy - year last 2 digits, ddd – day of the year, hh-hour, mm- minute)

NASA archive naming conventions:
(MOD021KM or MYD021KM).Ayyyyddd.hhmm.006.*.hdf 1km
(MOD02QKM or MYD02QKM).Ayyyyddd.hhmm.006.*.hdf 250m
(MOD03 or MYD03).Ayyyyddd.hhmm.006.*.hdf geolocation
(Where MYD-aqua, MOD-terra, yyyy – 4 digit year, ddd – day of the year, hh-hour, mm- minute)

MODIS L1B file	MODIS Polar2grid Bands Supported for GeoTIFF file creation
250m Ex: a1.13171.2033.250m.hdf or	**Visible Reflectance Bands** 1 (.65 µm), 2 (.86 µm)

MYD02QKM.A2013171.2033.*.hdf	
1 km Ex: a1.13171.2033.1000m.hdf or MYD021KM.A2013171.2033.*.hdf	**Visible Reflectance Bands** 1 (.65 µm), 2 (.86 µm), 3 (.47 µm), 4 (.55 µm), 5 (1.2 µm), 6 (1.6 µm), 7 (2.1 µm), 26 (1.38 µm) **Thermal Infrared Bands** 20 (3.75 µm), 21 (3.9 µm (fires)), 22 (3.9 µm), 23 (4.0 µm), 24 (4.4 µm), 25 (4.5 µm), 27 (6.7 µm), 28 (7.3 µm), 29 (8.5 µm), 30 (9.7 µm), 31 (11 µm), 32 (12.0µm), 33 (13.3 µm), 34 (13.6 µm), 35 (13.9 µm), 36 (14.2 µm)

It is recommended that all files be removed from the work directory before each new execution of the script.

The implementation of Polar2Grid to create AWIPS compatible files is very similar to that for GeoTIFFs as described in section 5.1. To execute the AWIPS processing script, you must provide the path and name of the MODIS Level 1B file or files, including the geolocation files, e.g.

```
modis2awips.sh -f /dat/a1.15234.1231.1000m.hdf /dat/a1.15234.1231.geo.hdf
```

This command will result in the creation of NetCDF-3 output files of all bands 1-7 and 20-36 that are found within the Aqua MODIS 1 km pass from 12:37 UTC, 22 August 2015. Since no specific AWIPS grid or grids were provided on input, all grids touched by the boundaries of the input data set will be created by default.

There are currently 4 AWIPS grids that are supported by `modis2awips.sh`:

- Grid 211e – East Contiguous US Grid at 1km resolution
- Grid 211w – West Contiguous US Grid at 1km resolution
- Grid 203 – Alaska Grid at 1km resolution
- Grid 204 – Pacific Grid (Hawaii) at 1km resolution

For more information on these AWIPS grid definitions, please see:
http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html

I can specify an AWIPS grid by using the `-g` option, followed by one or more of the supported grids. For example, I can execute the same command and create an Alaska grid reprojection by using this command,

```
modis2awips.sh -g 203 -f /dat/a1.15234.1231.1000m.hdf /dat/a1.15234.1231.geo.hdf
```

I can also point to a directory containing one MODIS L1B data set as long as the geolocation file is collocated. For instance, I could have shortened the previous command to

```
modis2awips.sh -g 203 -f /dat
```

if the Aqua MODIS L1B data files from 12:37 UTC, 22 August 2015 were the only ones located in the directory.

To create a band subset of reprojected MODIS output AWIPS files, the `--list-products` command provides a comprehensive list of all options available to `modis2awips.sh` from the provided input data. You can then select from these options in the command line using `-p`. For example, typing this command,

```
modis2awips.sh --list-products -f /dat
```

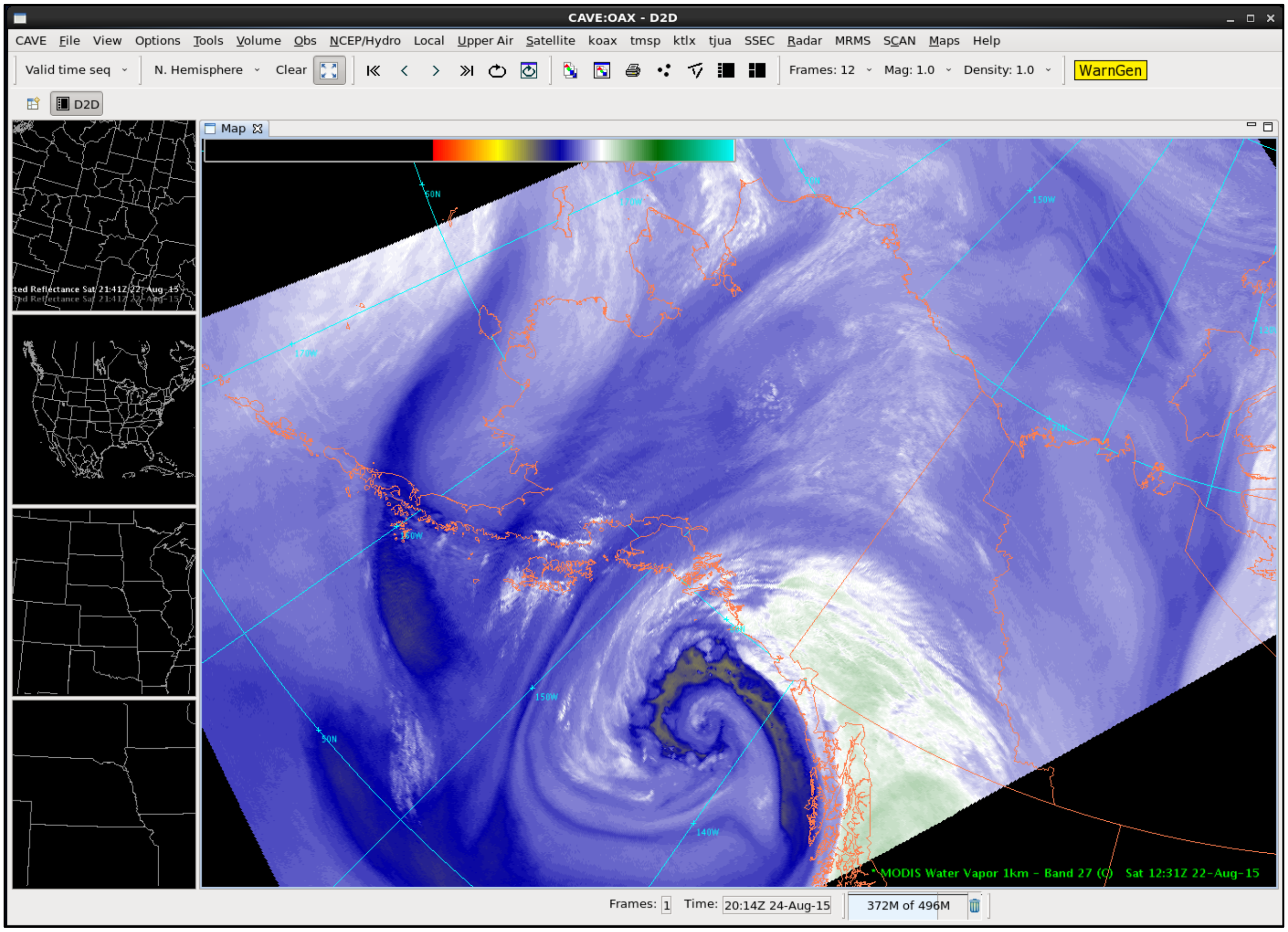
will output short names all of the different output product reprojections that can be made. Among those listed are each individual band,

…
bt20
bt21
bt22
bt23
bt24
bt25
bt27
bt28
bt29
bt30
bt31
bt32
bt33
bt34
bt35
bt36
…
vis01
vis02
vis03
vis04
vis05
vis06
vis07
vis26
…

You can then choose a subset from this list, by executing a command like this one,

```
modis2awips.sh -p bt20 bt27 bt28 bt31 -g 203 -f /dat
```

which will create individual AWIPS Alaska 1km gridded NetCDF3 output files for MODIS Thermal Infrared Bands 20, 27, 28 and 31. The figure below is an AWIPS-II screen display of MODIS Band 27 (6. 7 µm) from our 22 August 2015 test data set over the Alaska 203 grid domain.



Many other options are available for `modis2awips.sh`. A few are shown below. For a complete list of options, use `viirs2awips.sh -h`.

`modis2awips.sh`

- `-g <grid_name>` Grid names:
  - 211e – East Contiguous US Grid at 1km resolution.
  - 211w – West Contiguous US Grid at 1km resolution.
  - 203 – Alaska Grid at 1km resolution.
  - 204 – Pacific Grid (Hawaii) at 1km resolution.
- `--rescale-config <rescale configuration>` Specify the rescaling configuration to be used. Default depends upon data type. For more information, see: http://www.ssec.wisc.edu/software/polar2grid/rescaling.html .
- `-f <data_files>` Path and list of files to use. (**Required**)
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--bt-products` Create brightness temperatures images of all MODIS Infrared Bands.
- `--vis-products` Create reflectance images of all MODIS Visible Bands.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print helpful information.

```
modis2awips.sh -g 211e 211w -f /modis/MOD0{21KM,2QKM,3}.A2015232.1900.*.hdf
```

will create MODIS NetCDF 3 files for all of the supported bands on the CONUS 211 East and 211 West AWIPS 1km grids using the 1 km, 250m and geolocation found in the /modis directory from 20 August 2015, 19:00 UTC.

5.3.1 MODIS AWIPS Output File Naming Conventions

Upon successful execution of `modis2awips.sh`, one or more output files are produced, using this general standard naming convention,

SSEC_AWIPS_<sat>_modis _<cal><band>_ <awipsgrid>_ YYYYMMDD_HHMMS>.nc
Examples: SSEC_AWIPS_aqua_modis_bt20_203_20150822_123138.nc
SSEC_AWIPS_terra_modis_vis02_211w_20150820_190000.nc

Where,
sat is the Polar Orbiter Satellite platform (either aqua or terra),
cal is the band calibration (bt, vis or rad for brightness temperature, reflectance or radiance),
band is the MODIS instrument band number,
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second,
awipsgrid is the output 1km AWIPS grid number (211e, 211w, 203, 204)

5.4 Creating MODIS Reprojections in HDF5 format

Polar2Grid also has the capability to create reprojections and store them in Hierarchical Data Format version 5 (HDF5 or H5). The principal MODIS H5 processing script is `$POLAR2GRID_HOME/bin/modis2hdf5.sh`, which operates by default in the current directory. It creates intermediate files as well as final H5 output files. Each execution of `modis2hdf5.sh` creates a single output file containing the reprojected MODIS bands stored as arrays within the H5 file. Each band is represented as 32 bit floating point numbers. Any single reprojected grid cell that is not filled with data will be represented by NaNs (Not a Number) in the output H5 file. The default physical value stored for each band is dependent upon the band number, as show below.

- Reflectances for supported MODIS reflected solar bands (1-7, and 26),
- Brightness temperatures in degrees Kelvin for MODIS infrared bands (20-25,27-36).

If no bands are chosen, the default is to reproject and store as many bands as possible in the output H5 file depending on the input data.

As an example, executing this command,

```
modis2hdf5.sh -p vis01 bt20 latitude_1000m longitude_1000m -f
a1.15234.1231.{1000m,250m,geo}.hdf
```

will create a single reprojected output H5 file containing MODIS Band 1 reflectances, band 20 brightness temperatures, as well as reprojected latitude and longitudes created from the 1 km geolocation file. The data will be reprojected into the default Platte Carrée projection.

The output file also contains grid attribute information, including the proj4 definition, and the reprojected grid dimensions. You can use the HDF5 utility h5dump (http://www.hdfgroup.org/HDF5/doc/RM/Tools.html#Tools-Dump) to quickly browse through the file; the following shows attribute output from the MODIS Band 20 brightness temperature array.

```
h5dump -A aqua_modis_20150822_123138.h5

HDF5 "aqua_modis_20150822_123138.h5" {
GROUP "/" {
  GROUP "wgs84_fit" {
    ATTRIBUTE "cell_height" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): -0.0057
      }
    }
    ATTRIBUTE "cell_width" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): 0.0057
      }
    }
    ATTRIBUTE "height" {
      DATATYPE  H5T_STD_I64LE
      DATASPACE  SCALAR
      DATA {
      (0): 6628
      }
    }
    ATTRIBUTE "origin_x" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): 177.998
      }
    }
    ATTRIBUTE "origin_y" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): 82.1508
      }
    }
    ATTRIBUTE "proj4_definition" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
```

```
      CSET H5T_CSET_ASCII;
      CTYPE H5T_C_S1;
    }
    DATASPACE  SCALAR
    DATA {
    (0): "+proj=latlong +datum=WGS84 +ellps=WGS84 +no_defs"
    }
  }
  ATTRIBUTE "width" {
    DATATYPE  H5T_STD_I64LE
    DATASPACE  SCALAR
    DATA {
    (0): 14904
    }
  }
DATASET "bt20" {
    DATATYPE  H5T_IEEE_F32LE
    DATASPACE  SIMPLE { ( 6628, 14904 ) / ( 6628, 14904 ) }
    ATTRIBUTE "begin_time" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "2015-08-22T12:31:38"
      }
    }
    ATTRIBUTE "end_time" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "2015-08-22T12:40:56"
      }
    }
    ATTRIBUTE "instrument" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "modis"
      }
```

```
    }
    ATTRIBUTE "satellite" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "aqua"
      }
    }
  }
```

……………………………………..

Many other options are available for `modis2hdf5.sh`. A few are shown below. For a complete list of options, use `modis2hdf5.sh -h` .

`modis2hdf5.sh`

- `-g <grid_name>` grid names:

  Predefined grid names:
  - **wgs84_fit – Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

- `-f <data_files>` Path and list of files to use. (**Required**)
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--bt-products` Create brightness temperatures images of all MODIS Infrared Bands.
- `--vis-products` Create reflectance images of all MODIS Visible Bands.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.
- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

To use one of the predefined grids, I can execute a command like this,

```
viirs2hdf5.sh -g lcc_sa -f /modis/t1.15232.1000m.hdf /modis/t1.15232.geo.hdf
```

which will reproject all MODIS bands found in the `/modis/t1.15232.1000m.hdf` L1B file into a Lambert Conic Conformal projection suitable for locations in and around South America. The single output file will store the reprojected reflected solar bands as reflectances and the thermal infrared bands as brightness temperatures in Degrees Kelvin in the output HDF5 file as 32 bit floating point numbers.

5.4.1 MODIS AWIPS Output File Naming Conventions

Upon successful execution of `modis2hdf5.sh`, one or more output files are produced, using this general standard naming convention,

<sat>_modis _YYYYMMDD_HHMMS.h5
Example: aqua_modis_20150822_123138.h5

Where,

sat is the Polar Orbiter Satellite platform (either aqua or terra),
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second.

5.5 Creating MODIS Reprojections in Binary format

Polar2Grid also has the capability to create reprojections of MODIS radiance, brightness temperature, reflectances and geolocation parameters and store them as individual arrays in flat binary format. The principal MODIS binary processing script is `$POLAR2GRID_HOME/bin/modis2binary.sh`, which operates by default in the current directory. It creates intermediate files as well as final binary output files. Each execution of `modis2binary.sh` creates individual output files containing a single reprojected parameter. Each product is stored as 32 bit floating point numbers. Any single reprojected grid cell that is not filled with data will be represented by NaNs (Not a Number) in the output binary files. The default physical value stored for each band is dependent upon the band number, as show below.

- Reflectances for supported MODIS reflected solar bands (1-7, and 26),
- Brightness temperatures in degrees Kelvin for MODIS infrared bands (20-25,27-36).

If no bands are chosen, the default is to reproject and store as many bands as possible depending on the input data.

To see what products you can choose to reproject, use the `--list-products` optional argument, for example,

```
modis2binary.sh --list-products -f polar2grid_test/modis/input
```

Executing this command on the VIIRS test data set results in output like this,

```
INFO     : Initializing swath extractor...INFO     : Initializing swath
extractor...
bt20
bt21
bt22
bt23
bt24
bt25
bt27
bt28
bt29
bt30
bt31
bt32
bt33
bt34
bt35
bt36
…
latitude_1000m
latitude_250m
latitude_500m
longitude_1000m
longitude_250m
longitude_500m
solar_zenith_angle
vis01
vis02
vis03
vis04
vis05
vis06
vis07
vis26
```

The results show the bands available, including visible reflectances (for example, vis01, vis26), brightness temperatures (for example, bt20, bt36), as well as geolocation and geometry parameters (for example, latitude_250m, solar_zenith_angle). I can then choose parameters from the list to create the output files that I want.

As an example, I can execute this command to create binary output file reprojections of MODIS visible Band 1 reflectances, MODIS Band 31 brightness temperatures and 1 km latitude and longitude from our Aqua MODIS test data set acquired on 20 June 2013.

```
modis2binary.sh -p vis01 bt31 latitude_1000m longitude_1000m -f
polar2grid_test/modis/input
```

As the output files are being created, the Polar2Grid standard text output will display the grid parameters including the width and height of the grid reprojection of your data set. In this case, we used the default Platte Carrée reprojection, which results in this grid information,

```
INFO    : Grid information:
        grid_name: wgs84_fit
```

proj4_definition: +proj=latlong +datum=WGS84 +ellps=WGS84 +no_defs
cell_width: 0.0057
cell_height: -0.0057
width: 6065
height: 3781
origin_x: -132.280456543
origin_y: 53.4550476074

This information is also available in the output log file created with each script execution. The output consists of 4 binary files, one for each requested parameter.

```
aqua_modis_bt31_20130620_203500_wgs84_fit.dat
aqua_modis_latitude_1000m_20130620_203500_wgs84_fit.dat
aqua_modis_longitude_1000m_20130620_203500_wgs84_fit.dat
aqua_modis_vis01_20130620_203500_wgs84_fit.dat
```

Each file contains the parameters on the output grid stored as 32 bit floating point numbers. There is no header data in the file. Therefore, the output file size can be computed as, grid width * grid height * 4 bytes per cell. In our example, the files size for each parameter is then,

6484 * 3449 * 4 = 91727060 bytes.

Many other options are available for `modis2binary.sh`. A few are shown below. For a complete list of options, use `modis2binary.sh -h`.

`modis2binary.sh`

- `-g <grid_name>` grid names:
  Predefined grid names:
  - **wgs84_fit – Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

- `-f <data_files>` Path and list of files to use. (**Required**)
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--bt-products` Create brightness temperatures images of all MODIS Infrared Bands.
- `--vis-products` Create reflectance images of all MODIS Visible Bands.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.

- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

To use one of the predefined grids, I can execute a command like this,

```
modis2binary.sh -g lcc_na -f polar2grid_test/modis/input
```

which will reproject all MODIS files found in the `polar2grid_test/modis/input` directory into a Lambert Conic Conformal 1 km projection suitable for regions in and around North America, and store the reprojected data in individual product files as 32 bit floating point numbers.

5.5.1 VIIRS Binary Output File Naming Conventions

Upon successful execution of `modis2binary.sh`, one or more output files are produced, using this genral standard naming convention,

<sat>_modis _<product>_YYYYMMDD_HHMMS_<projection>.dat
Examples: npp_viirs_i01_20140617_194654_wgs84_fit.dat
npp_viirs_i05_20140617_194654_wgs84_fit.dat
npp_viirs_i_longitude_20140617_194654_wgs84_fit.dat

Where,
sat is the Polar Orbiter Satellite platform (either aqua or terra),
product is the VIIRS parameter name,
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second,
projection is the grid being projected to.

5.6 Running the MODIS Polar2Grid Test Cases

To run the MODIS test case, unpack the test data as shown in Section 2.1 and then execute the commands below:

```
cd polar2grid_test/modis
mkdir work
cd work
crefl2gtiff.sh false_color --false-color --true-color --grid-configs
${POLAR2GRID_HOME}/grid_configs/grid_example.conf -g grand_canyon -f
../input/MYD0{3,21KM,2HKM,2QKM}.A2013171.2035.*.hdf
```

The test case consists of an input direct broadcast pass set of Aqua MODIS L1B 1000m, 500m, 250m and geolocation files. In this test, the polar2grid software is using the example configuration file (`${POLAR2GRID_HOME}/grid_configs/grid_example.conf)` and the lambert conformal conic (lcc) “grand_canyon” grid definition entry located within it:

grand_canyon, proj4, +proj=lcc +datum=WGS84 +ellps=WGS84 +lat_0=36.100 +lat_1=36.100 +lon_0=-112.100 +units=m +no_defs, 1000, 750, 500.000, -500.000, -114.936deg, 37.756deg

It will create an image at 500 m resolution, 1000 lines x 750 elements centered on the US Grand Canyon region (36.1 N, 112 W). The processing should run in 1 to 2 minutes and create 8 crefl output MODIS GeoTIFF files, including both true and false color output images and the individual Corrected Reflectance images that went into producing the final products. If the MODIS polar2grid processing script runs normally, it will return a status code equal to zero. If the MODIS polar2grid processing script encounters a fatal error, it will return a non-zero status code.

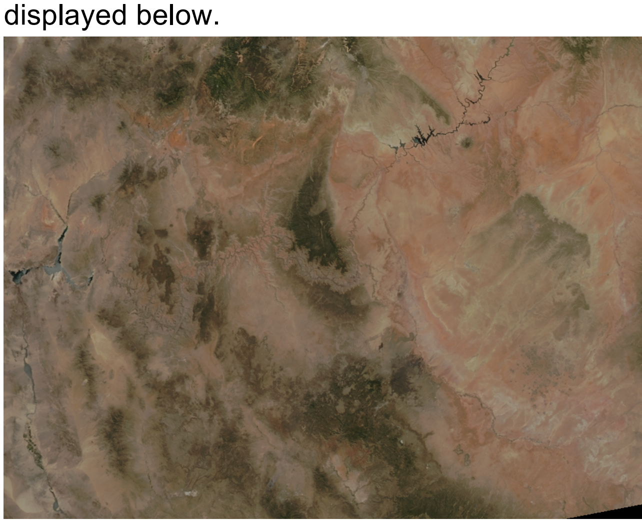
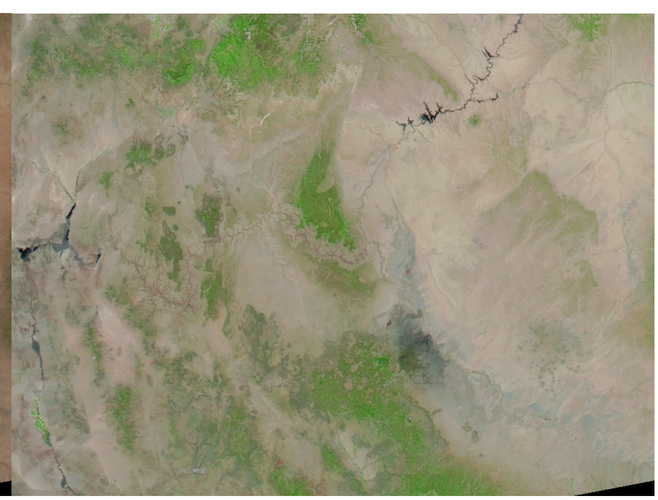
To verify your output files against the output files created at UW/SSEC, execute the following commands:

```
cd ..
./p2g_compare_geotiff.sh output work
```

This script compares the values of all the GeoTiFF files for all MODIS files. The output from our test system are shown below. If you see similar output, the test was successful.

```
./p2g_compare_geotiff.sh output work
Comparing work/aqua_modis_false_color_20130620_203500_grand_canyon.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/aqua_modis_modis_crefl01_1000m_20130620_203500_grand_canyon.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/aqua_modis_modis_crefl01_250m_20130620_203500_grand_canyon.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/aqua_modis_modis_crefl02_1000m_20130620_203500_grand_canyon.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/aqua_modis_modis_crefl03_1000m_20130620_203500_grand_canyon.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/aqua_modis_modis_crefl04_1000m_20130620_203500_grand_canyon.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/aqua_modis_modis_crefl07_1000m_20130620_203500_grand_canyon.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
Comparing work/aqua_modis_true_color_20130620_203500_grand_canyon.tif to known valid file
SUCCESS: 0 pixels out of 750000 pixels are different
All files passed
SUCCESS
```

The output MODIS true color and false color GeoTIFF file images created using the test data are displayed below.

MODIS True Color Grand Canyon Image

MODIS False Color Grand Canyon Image

Further image enhancement can be performed using the ImageMagick® "convert" utility, which is freely distributed from this website:

http://www.imagemagick.org/script/index.php

As an example, to sharpen and enhance our true and false color images and convert them from .tif to .jpg format, you could use these commands:

```
convert -sigmoidal-contrast 3,50% -modulate 100,125,100 -gamma 1.1 -unsharp 0 -quality 90 \
aqua_modis_true_color_20130620_203500_grand_canyon.tif \
aqua_modis_true_color_20130620_203500_grand_canyon.jpg

convert -sigmoidal-contrast 3,50% -modulate 100,125,100 -gamma 1.1 -unsharp 0 -quality 90 \
aqua_modis_false_color_20130620_203500_grand_canyon.tif \
aqua_modis_false_color_20130620_203500_grand_canyon.jpg
```

The `aqua_modis_true_color_20130620_203500_grand_canyon.jpg` and `aqua_modis_false_color_20130620_203500_grand_canyon.jpg` that were created by executing this command are included in the polar2grid_test/modis/output directory.

5.6.2 Running the MODIS to AWIPS test case

To run the Polar2Grid MODIS to AWIPS test case, unpack the test data as shown in Section 2.1 and then execute the commands below:

```
cd polar2grid_test/modis
mkdir work_awips
cd work_awips
modis2awips.sh -p vis01 vis02 vis07 bt27 bt31 -g 211w -f ../input/*.hdf
```

The test case consists of Aqua MODIS L1B files from a 5 minute data granule from 20 June 2013, 20:35 UTC. The polar2grid software should run in less than 1 minute and create 5 output MODIS NetCDF3 files (MODIS Bands 1, 2, 7, 27 and 31) consisting of scaled integers ranging from 0 to 255 on the AWIPS 1km West CONUS grid 211w. If the MODIS polar2grid processing script runs normally, it will return a status code equal to zero. If the MODIS polar2grid processing script encounters a fatal error, it will return a non-zero status code.

To verify your output files against the output files created at UW/SSEC, execute the following commands:

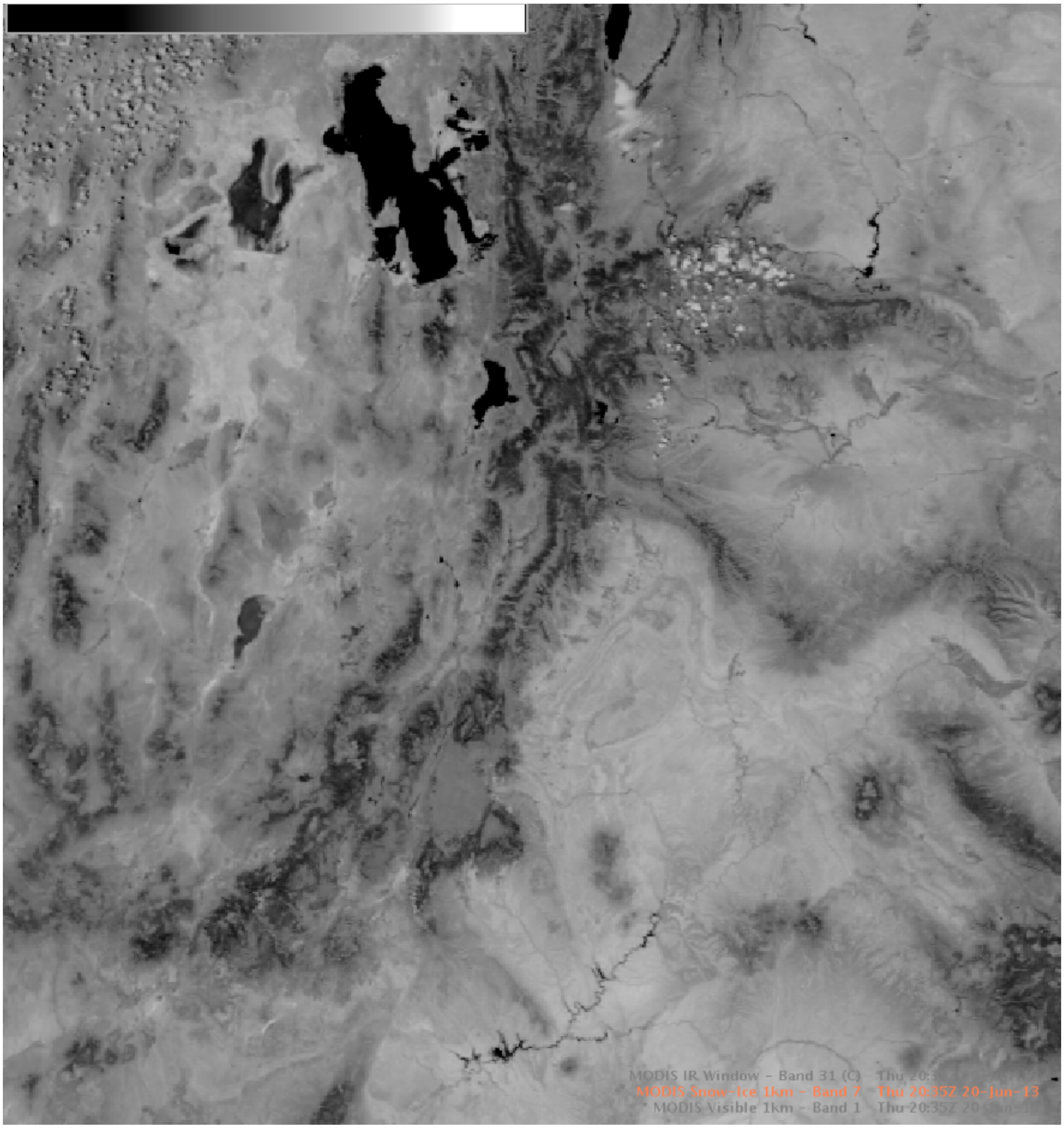
```
cd ..
./p2g_compare_netcdf.sh output work_awips
```

This script compares the values of all the NetCDF files for all of the VIIRS Bands. The output from our test system are shown below. If you see similar output, the test was successful.

```
./p2g_compare_netcdf.sh output work_awips
Comparing work/SSEC_AWIPS_aqua_modis_bt27_211w_20130620_203500.nc to known valid file
SUCCESS: 0 pixels out of 22528000 pixels are different
Comparing work/SSEC_AWIPS_aqua_modis_bt31_211w_20130620_203500.nc to known valid file
SUCCESS: 0 pixels out of 22528000 pixels are different
Comparing work/SSEC_AWIPS_aqua_modis_vis01_211w_20130620_203500.nc to known valid file
SUCCESS: 0 pixels out of 22528000 pixels are different
Comparing work/SSEC_AWIPS_aqua_modis_vis02_211w_20130620_203500.nc to known valid file
```

```
SUCCESS: 0 pixels out of 22528000 pixels are different
Comparing work/SSEC_AWIPS_aqua_modis_vis07_211w_20130620_203500.nc to known valid file
SUCCESS: 0 pixels out of 22528000 pixels are different
All files passed
SUCCESS
```

A screen capture of the MODIS AWIPS NetCDF3 file, SSEC_AWIPS_aqua_modis_vis07_211w_20130620_203500.nc, as displayed in AWIPS-II is shown below.



Section 6: Creating AVHRR Reprojections

Polar2grid Version 2.0 includes the capability to reproject Advanced Very High Resolution Radiometer (AVHRR) High Rate Picture Transmission (HRPT) data using input generated by the ATOVS and AVHRR Pre-processing Package (AAPP) in Level 1b binary format. Polar2grid supports this AVHRR L1b from the following satellites:

- NOAA-18,
- NOAA-19,
- Metop-A and
- Metop-B satellites.

Example input filenames are:

hrpt_noaa19_20150824_2004_33692.l1b (NOAA-19 AVHRR)
hrpt_M01_20150811_2123_15033.l1b (Metop-B AVHRR).

6.1 Creating AVHRR SDR Single Band GeoTIFF files

The principal AVHRR GeoTIFF processing script is `$POLAR2GRID_HOME/bin/avhrr2gtiff.sh`, which operates by default in the current directory. It creates intermediate files as well as final GeoTIFF (*.tif) output files. More than one dataset can be used at a time; if more that one file is presented as input, an aggregated image will be created. It is recommended that all files be removed from the work directory before each new execution of the script. To execute the GeoTIFF processing script, you must provide the path and name of the VIIRS SDR file or files. The standard execution is:

```
avhrr2gtiff.sh -f /path_to_AVHRR_L1b_file(s)
```

For example, executing this command,

```
avhrr2gtiff.sh -f /P2G/avhrr/hrpt_noaa19_20150824_2004_33692.l1b
```

will result in the generation of reprojected GeoTIFF images for all bands that are available in the this HRPT NOAA-19 AVHRR data set from 24 August 2015, 20:04 UTC. The output files will be created in the default Platte Carrée projection.

Use the `--list-products` option to view all potential GeoTIFF products that can be created from the given input data.

```
avhrr2gtiff.sh --list-products -f /P2G/avhrr/hrpt_noaa19_20150824_2004_33692.l1b
```

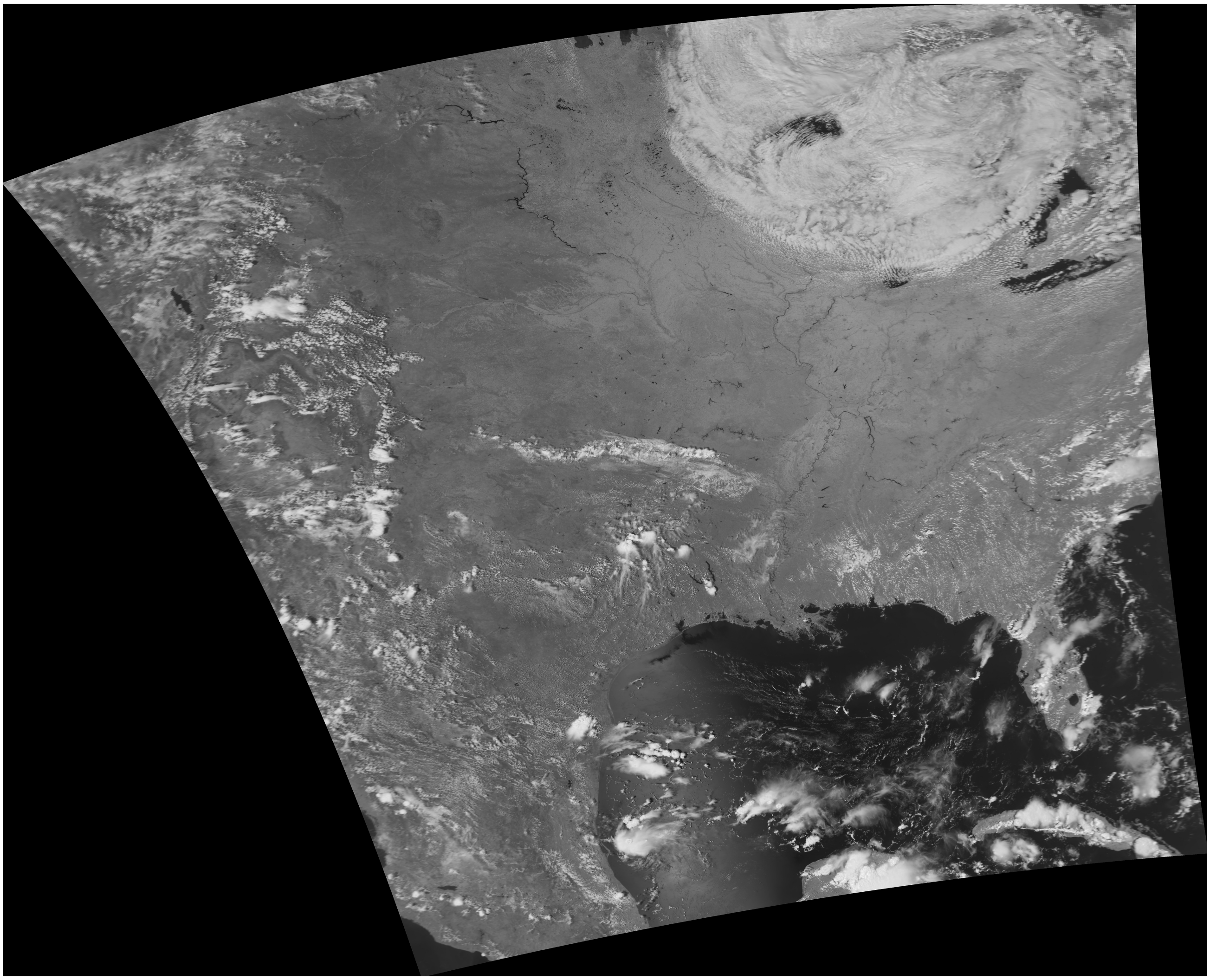
Executing this command provides a standard list of products available for all AVHRR data sets. Please note that not all bands are available for all AVHRR instruments (i.e., band3a_vis).

```
band1_vis
band2_vis
band3a_vis
band3b_bt
band4_bt
band5_bt
latitude1km
longitude1km
```

Once you have this list, you can use the `-p` option to choose a subset of the bands to reproject,

```
avhrr2gtiff.sh -p band2_vis -f /P2G/avhrr/hrpt_noaa19_20150824_2004_33692.l1b
```

Executing this command will create one reprojected GeoTIFF file of the NOAA-19 AVHRR Band 2 Solar Reflectances (.86 μm) from our 24 August 2015 data set in the default Platte Carrée projection. The image created from executing this command is displayed below.



Many other options are available for `avhrr2gtiff.sh`. A few are shown below. For a complete list of options, use `avhrr2gtiff.sh -h`.

`avhrr2gtiff.sh`

- `-g <grid_name>` Specify the output grid to use. Default is the Platte Carrée projection, also known as the wgs84 coordinate system. – For more details, see:
  http://www.ssec.wisc.edu/software/polar2grid/grids.html
  Predefined grid names:
  - **wgs84_fit – Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.

- **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
- **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
- **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
- Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

- `--rescale-config <rescale configuration>` Specify the rescaling configuration to be used. Default depends upon data type. For more information, see: http://www.ssec.wisc.edu/software/polar2grid/rescaling.html .
- `-f <data_files>` Path and list of files to use. (**Required**)
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.
- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

To use one of predefined global grids, I could use a command like this one,

```
avhrr2gtiff.sh -g lcc_eu -f /data/hrpt_M01_20150811_2123_15033.l1b
```

which would result in the creation of reprojected GeoTIFFs from all AVHRR bands found in the Metop-B dataset from 11 August 2015, 21:23 UTC. The reprojection used is the Lambert Conic Conformal centered on Europe.

6.1.1 AVHRR GeoTIFF Output File Naming Conventions

Upon successful execution of `avhrr2gtiff.sh`, one or more output files are produced, using this general standard naming convention,

<sat>_avhrr_band<no>_<cal>_YYYYMMDD_HHMMSS_<projection>.tif
Example: noaa19_avhrr_band1_vis_20150824_200424_wgs84_fit.tif
metopb_avhrr_band3a_vis_20150811_212312_wgs84_fit.tif

Where,

sat is the Polar Orbiter Satellite platform (noaa18, noaa19, metopa or metopb),
no is the AVHRR instrument band number,
cal is the band calibration (bt or vis for brightness temperature or reflectance),
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second,
projection is the grid being projected to.

6.2 Creating AVHRR AWIPS Compliant NetCDF3 Files

Polar2Grid is also able to create AWIPS compliant files on National Weather Service (NWS) grids. The principal AVHRR AWIPS processing script is `$POLAR2GRID_HOME/bin/avhrr2awips.sh`, which operates by default in the current directory. It creates intermediate files as well as final NetCDF-3 output files of byte values scaled from 0-255 using a standardized set of output filenames. The software will create AWIPS files for as many bands as requested by the user; the default is to produce as many bands as possible depending on the input data.

The implementation of Polar2Grid to create AWIPS compatible files is very similar to that for GeoTIFFs as described in section 6.1. To execute the AWIPS processing script, you must provide the path and name of the AVHRR SDR file or files, for example,

```
avhrr2awips.sh -f /data/metopb/hrpt_M01_20150811_2123_15033.l1b
```

This command will create NetCDF-3 output files using the Metop-B dataset from 11 August 2015 beginning at 21:23 UTC. Since no specific grid was provided, the software will compare the data geographic boundaries with all supported grids and produce as many as possible. There are currently 4 AWIPS grids that are supported by `avhrr2awips.sh`:

- Grid 211e – East Contiguous US Grid at 1km resolution
- Grid 211w – West Contiguous US Grid at 1km resolution
- Grid 203 – Alaska Grid at 1km resolution
- Grid 204 – Pacific Grid (Hawaii) at 1km resolution

For more information on these AWIPS grid definitions, please see:
http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html

I can specify an AWIPS grid by using the `-g` option, followed by one or more of the supported grids. For example, I can create an Alaska grid reprojection by using this command,

```
avhrr2awips.sh -g 203 -f /data/metopb/hrpt_M01_20150811_2123_15033.l1b
```

I can also point to a directory containing an AVHRR data set as well. For instance, I could have shortened the previous command to

```
modis2awips.sh -g 203 -f /data/metopb
```

if the Metop-B AVHRR HRPT file was the only one stored in the directory.

To create a band subset of reprojected AVHRR AWIPS files, the `--list-products` command provides a comprehensive list of all options available to `avhrr2awips.sh` from the provided input data. You can then select from these options in the command line using `-p`. For example, typing this command,

```
modis2awips.sh --list-products -f /data/metopb
```

will output short names all of the different output product reprojections that can be made. Among those listed are each individual band. Please note that not all bands are available for all AVHRR instruments,

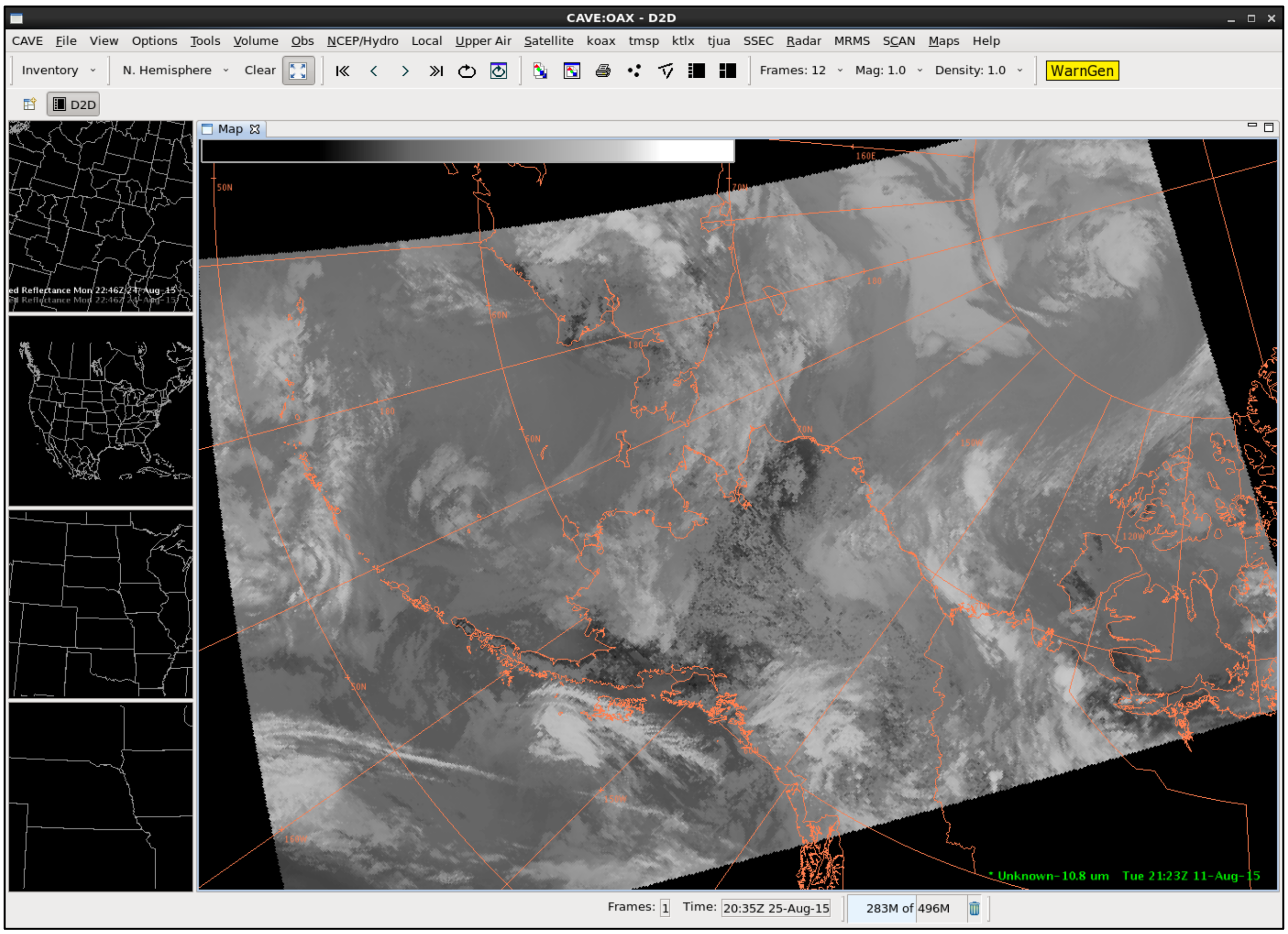
band1_vis

band2_vis
band3a_vis
band3b_bt
band4_bt
band5_bt

You can then specify a subset from this list, by executing a command like this one,

```
modis2awips.sh -p band3a_vis band4_bt -g 203 -f /data/metopb
```

which will create individual AWIPS Alaska 1km gridded NetCDF3 output files for AVHRR visible band 3 (1.6 µm) and thermal Infrared Band 4 (10.8 µm). The figure below is an AWIPS-II screen display of AVHRR Infrared Band 4 (10.8 µm) brightness temperatures from our 11 August 2015 test data set over the Alaska 203 grid domain.



Many other options are available for `avhrr2awips.sh`. A few are shown below. For a complete list of options, use `avhrr2awips.sh -h`.

`avhrr2awips.sh`

- `-g <grid_name>` Grid names:
    - 211e – East Contiguous US Grid at 1km resolution.
    - 211w – West Contiguous US Grid at 1km resolution.
    - 203 – Alaska Grid at 1km resolution.
    - 204 – Pacific Grid (Hawaii) at 1km resolution.

- `--rescale-config <rescale configuration>` Specify the rescaling configuration to be used. Default depends upon data type. For more information, see: http://www.ssec.wisc.edu/software/polar2grid/rescaling.html .
- `-f <data_files>` Path and list of files to use. (**Required**)
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print detailed help information.

```
avhrr2awips.sh -g 211e 211w -f /P2G/avhrr/hrpt_noaa19_20150824_2004_33692.l1b
```

Executing this command, will result in the creation of AVHRR NetCDF 3 files for all of the supported bands on the CONUS 211 East and 211 West AWIPS 1km grids using the NOAA-19 HRPT pass file from 24 August 2015, 20:04 UTC.

6.2.1 AVHRR AWIPS Output File Naming Conventions

Upon successful execution of `avhrr2awips.sh`, one or more output files are produced, using this general standard naming convention,

SSEC_AWIPS_<sat>_avhrr_band<no>_<cal>_<awipsgrid>_ YYYYMMDD_HHMMS>.nc
Example: SSEC_AWIPS_metopb_avhrr_band3a_vis_203_20150811_212312.nc
SSEC_AWIPS_noaa19_avhrr_band3b_bt_211e_20150824_200424.nc

Where,
sat is the Polar Orbiter Satellite platform (noaa18, noaa19, metopa or metopb),
no is the AVHRR instrument band number,
cal is the band calibration (bt or vis for brightness temperature or reflectance),
awipsgrid is the output 1km AWIPS grid number (211e, 211w, 203, 204),
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second.

6.3 Creating AVHRR Reprojections in HDF5 format

Polar2Grid also has the capability to create reprojections and store them in Hierarchical Data Format version 5 (HDF5 or H5). The principal AVHRR H5 processing script is `$POLAR2GRID_HOME/bin/avhrr2hdf5.sh`, which operates by default in the current directory. It creates intermediate files as well as final H5 output files. Each execution of `avhrr2hdf5.sh` creates a single output file containing the AVHRR bands stored as arrays within the H5 file. Each band is represented as 32 bit floating point numbers. Any single reprojected grid cell that is not filled with data will be represented by NaNs (Not a Number) in the output H5 file. The default physical value stored for each band is dependent upon the band number, as show below:

- Reflectances AVHRR reflected solar bands (1, 2, 3a),
- Brightness temperatures in degrees Kelvin for AVHRR infrared bands (3b,4, 5).

If no bands are chosen, the default is to reproject and store as many bands as possible in the output H5 file depending on the input data.

As an example, executing this command,

```
avhrr2hdf5.sh -p band1_vis band3b_bt latitude1km longitude1km -f
/data/hrpt_noaa18_20150824_0018_52865.l1b
```

will create a single reprojected output H5 file containing AVHRR Band 1 reflectances, band 3b brightness temperatures, as well as reprojected latitude and longitudes. The data will be reprojected into the default Platte Carrée projection.

The output file also contains grid attribute information, including the proj4 definition, and the reprojected grid dimensions. You can use the HDF5 utility h5dump (http://www.hdfgroup.org/HDF5/doc/RM/Tools.html#Tools-Dump) to quickly browse through the file; the following shows attribute output from the AVHRR Band 1 reflectance array.

h5dump -A noaa18_avhrr_20150824_001808.h5

```
HDF5 "noaa18_avhrr_20150824_001808.h5" {
GROUP "/" {
  GROUP "wgs84_fit" {
    ATTRIBUTE "cell_height" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): -0.0057
      }
    }
    ATTRIBUTE "cell_width" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): 0.0057
      }
    }
    ATTRIBUTE "height" {
      DATATYPE  H5T_STD_I64LE
      DATASPACE  SCALAR
      DATA {
      (0): 5594
      }
    }
    ATTRIBUTE "origin_x" {
      DATATYPE  H5T_IEEE_F64LE
      DATASPACE  SCALAR
      DATA {
      (0): -141.002
      }
    }
    ATTRIBUTE "origin_y" {
      DATATYPE  H5T_IEEE_F64LE
```

```
      DATASPACE  SCALAR
      DATA {
      (0): 55.8911
      }
    }
    ATTRIBUTE "proj4_definition" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "+proj=latlong +datum=WGS84 +ellps=WGS84 +no_defs"
      }
    }
    ATTRIBUTE "width" {
      DATATYPE  H5T_STD_I64LE
      DATASPACE  SCALAR
      DATA {
      (0): 7973
      }
    }
 DATASET "band3b_bt" {
      DATATYPE  H5T_IEEE_F32LE
      DATASPACE  SIMPLE { ( 5594, 7973 ) / ( 5594, 7973 ) }
      ATTRIBUTE "begin_time" {
        DATATYPE  H5T_STRING {
          STRSIZE H5T_VARIABLE;
          STRPAD H5T_STR_NULLTERM;
          CSET H5T_CSET_ASCII;
          CTYPE H5T_C_S1;
        }
        DATASPACE  SCALAR
        DATA {
        (0): "2015-08-24T00:18:08.783000"
        }
      }
      ATTRIBUTE "end_time" {
        DATATYPE  H5T_STRING {
          STRSIZE H5T_VARIABLE;
          STRPAD H5T_STR_NULLTERM;
          CSET H5T_CSET_ASCII;
          CTYPE H5T_C_S1;
        }
        DATASPACE  SCALAR
        DATA {
        (0): "2015-08-24T00:26:00.950000"
        }
      }
      ATTRIBUTE "instrument" {
        DATATYPE  H5T_STRING {
```

```
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "avhrr"
      }
    }
    ATTRIBUTE "satellite" {
      DATATYPE  H5T_STRING {
        STRSIZE H5T_VARIABLE;
        STRPAD H5T_STR_NULLTERM;
        CSET H5T_CSET_ASCII;
        CTYPE H5T_C_S1;
      }
      DATASPACE  SCALAR
      DATA {
      (0): "noaa18"
      }
    }
  }
```

Many other options are available for `avhrr2hdf5.sh`. A few are shown below. For a complete list of options, use `avhrr2hdf5.sh -h`.

`avhrr2hdf5.sh`

- `-g <grid_name>` grid names:
  Predefined grid names:
  - **wgs84_fit** – **Default.** Platte Carrée projection .0057 degree (mid latitudes ≈600m) resolution.
  - **wgs84_fit_250** - Platte Carrée projection. .0025 degree (mid latitudes ≈250m) resolution.
  - **polar_north_pacific** – Polar Stereographic projection. 400 m grid – use for Northern High Latitudes.
  - **polar_south_pacific** – Polar Stereographic projection. 400 m grid – use for Southern High Latitudes.
  - **lcc_fit_hr** – 400 m East Contiguous US centered Lambert Conformal Conic
  - Lambert Conic Conformal (LCC) 1km predefined continental grids:

lcc_na - North America	**lcc_south_africa** - South Africa
lcc_sa - South America	**lcc_aus** - Australia
lcc_eu - Europe and North Africa	**lcc_asia** - Asia

-
- `-f <data_files>` Path and list of files to use. (**Required**)
- `--list-products` List all possible product options to use with `-p`.
- `-p` List of products to create. Default is to create all possible band images based upon input.
- `--grid-coverage` Percentage of grid that must be covered by data. **Default is 10%.**
- `--debug` Don't remove intermediate files upon completion.
- `-v` Print detailed log information.
- `-h` Print helpful information.

- `--grid-configs <grid configuration file name>` Specify the path and name of the grid configuration file that contains grid names and their definitions. This option is useful if you want to define your own local grids (See **Appendix 1** for more information).

To use one of the predefined grids, I can execute a command like this,

```
avhrr2hdf5.sh -g lcc_asia -f /avhrr/hrpt_M02_20150825_1402_45896.l1b.h5
```

which will reproject all AVHRR specrtral bands found in the `/avhrr/hrpt_M02_20150825_1402_45896.l1b` Metop-A AVHRR L1b file into a Lambert Conic Conformal projection suitable for locations in and around the Asian continent. The single output file will store the reprojected reflected solar bands as reflectances and the thermal infrared bands as brightness temperatures in Degrees Kelvin in the output HDF5 file as 32 bit floating point numbers.

6.3.1 AVHRR HDF5 Output File Naming Conventions

Upon successful execution of `avhrr2hdf5.sh`, one or more output files are produced, using this general standard naming convention,

<sat>_avhrr_YYYYMMDD_HHMMSS.h5
Example: noaa18_avhrr_20150824_001808.h5

Where,
sat is the Polar Orbiter Satellite platform (noaa18, noaa19, metopa or metopb),
YYYY is the data year,
MM is the data month,
DD is the data day of the month,
HH is the data pass start time hour (0-24) in UTC,
MM is the data pass start time minute,
SS is the data pass start time second.

6.4 Running the AVHRR Polar2Grid Test Cases

6.4.1 Running the AVHRR Polar2grid GeoTIFF test case

To run the AVHRR GeoTIFF test case, unpack the test data as shown in Section 2.1 and then execute the commands below:

```
cd polar2grid_test/avhrr
mkdir work
cd work
avhrr2gtiff.sh --grid-configs
${POLAR2GRID_HOME}/grid_configs/grid_example.conf -g barrow -f ../input
```

The test case consists of one input Metop-B direct broadcast Level 1b file from 22 July 2015, 19:56 UTC. In this test, the polar2grid software is using the example configuration file (`${POLAR2GRID_HOME}/grid_configs/grid_example.conf`) and the polar stereographic (stere) “barrow” Alaska grid definition entry located within it. This execution creates GeoTIFF output files for each AVHRR band included in the file. The grid configuration results in output files that are 750 lines x 750 elements at 1000m resolution centered on Barrow, Alaska. The processing should run in less than 1 minute and create 5 output AVHRR GeoTIFF files. If the AVHRR polar2grid processing script runs normally, it will return a status code equal to zero. If the AVHRR polar2grid processing script encounters a fatal error, it will return a non-zero status code.

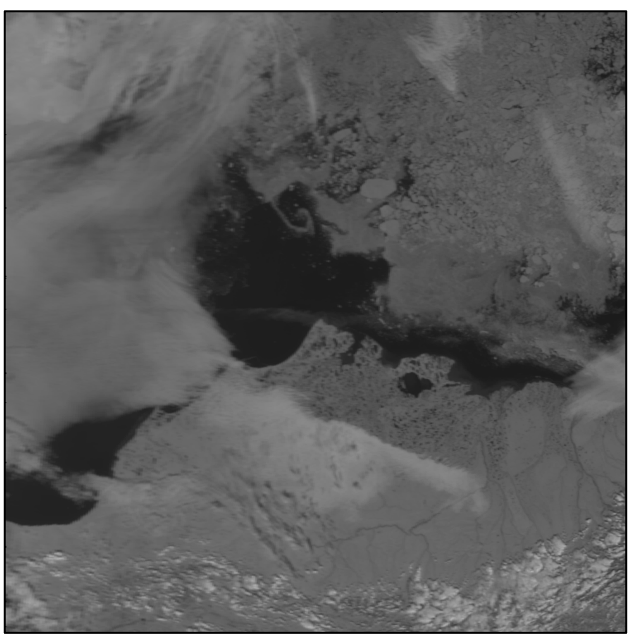
To verify your output files against the output files created at UW/SSEC, execute the following commands:

```
cd ..
./p2g_compare_geotiff.sh output work
```

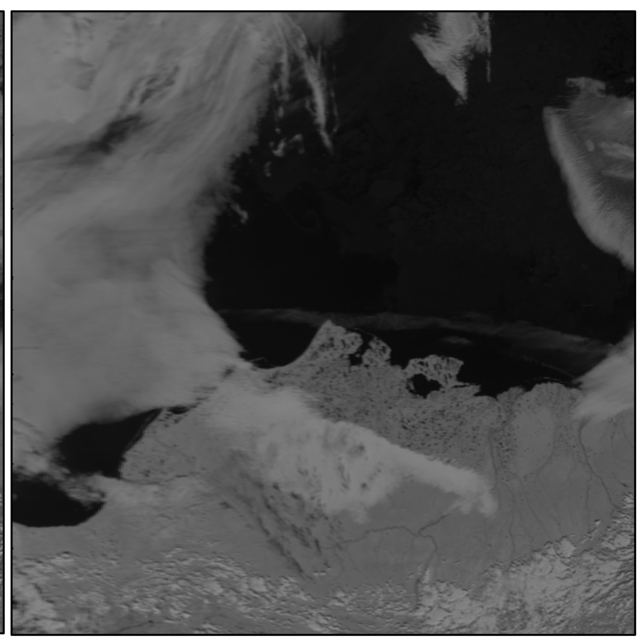
This script compares the values of all the GeoTiFF files found in the work directory. The output from our test system is shown below. If you see similar output, the test was successful.

```
./p2g_compare_geotiff.sh output work
Comparing work/metopb_avhrr_band1_vis_20150722_195652_barrow.tif to known valid file
SUCCESS: 0 pixels out of 562500 pixels are different
Comparing work/metopb_avhrr_band2_vis_20150722_195652_barrow.tif to known valid file
SUCCESS: 0 pixels out of 562500 pixels are different
Comparing work/metopb_avhrr_band3a_vis_20150722_195652_barrow.tif to known valid file
SUCCESS: 0 pixels out of 562500 pixels are different
Comparing work/metopb_avhrr_band4_bt_20150722_195652_barrow.tif to known valid file
SUCCESS: 0 pixels out of 562500 pixels are different
Comparing work/metopb_avhrr_band5_bt_20150722_195652_barrow.tif to known valid file
SUCCESS: 0 pixels out of 562500 pixels are different
All files passed
SUCCESS
```

The output AVHRR Visible Band 2 (.86 µm) and Visible Band 3a (1.6 µm) .tif files,
`metopb_avhrr_band2_vis_20150722_195652_barrow.tif`
`metopb_avhrr_band3a_vis_20150722_195652_barrow.tif`, are shown below.



AVHRR Band 2 Barrow, Alaska Reprojection



AVHRR Band 3a Barrow, Alaska Reprojection

6.4.2 Running the VIIRS to AWIPS test case

To run the Polar2Grid AVHRR to AWIPS test case, unpack the test data as shown in Section 2.1 and then execute the commands below:

```
cd polar2grid_test/avhrr
mkdir work_awips
cd work_awips
avhrr2awips.sh -g 203 -p band2_vis -f band2_vis ../input
```

The test case consists of an input direct broadcast Level 1b Metop-B file from 22 July 2015, 19:56 UTC acquired in Alaska. The polar2grid software should run in less than 1 minute and create 1 output AVHRR NetCDF3 visible Band 2 (.86 µm) file consisting of scaled integers ranging from 0 to 255 on the AWIPS Alaska grid 203. If the AVHRR polar2grid processing script runs normally, it will return a status code equal to zero. If the AVHRR polar2grid processing script encounters a fatal error, it will return a non-zero status code.

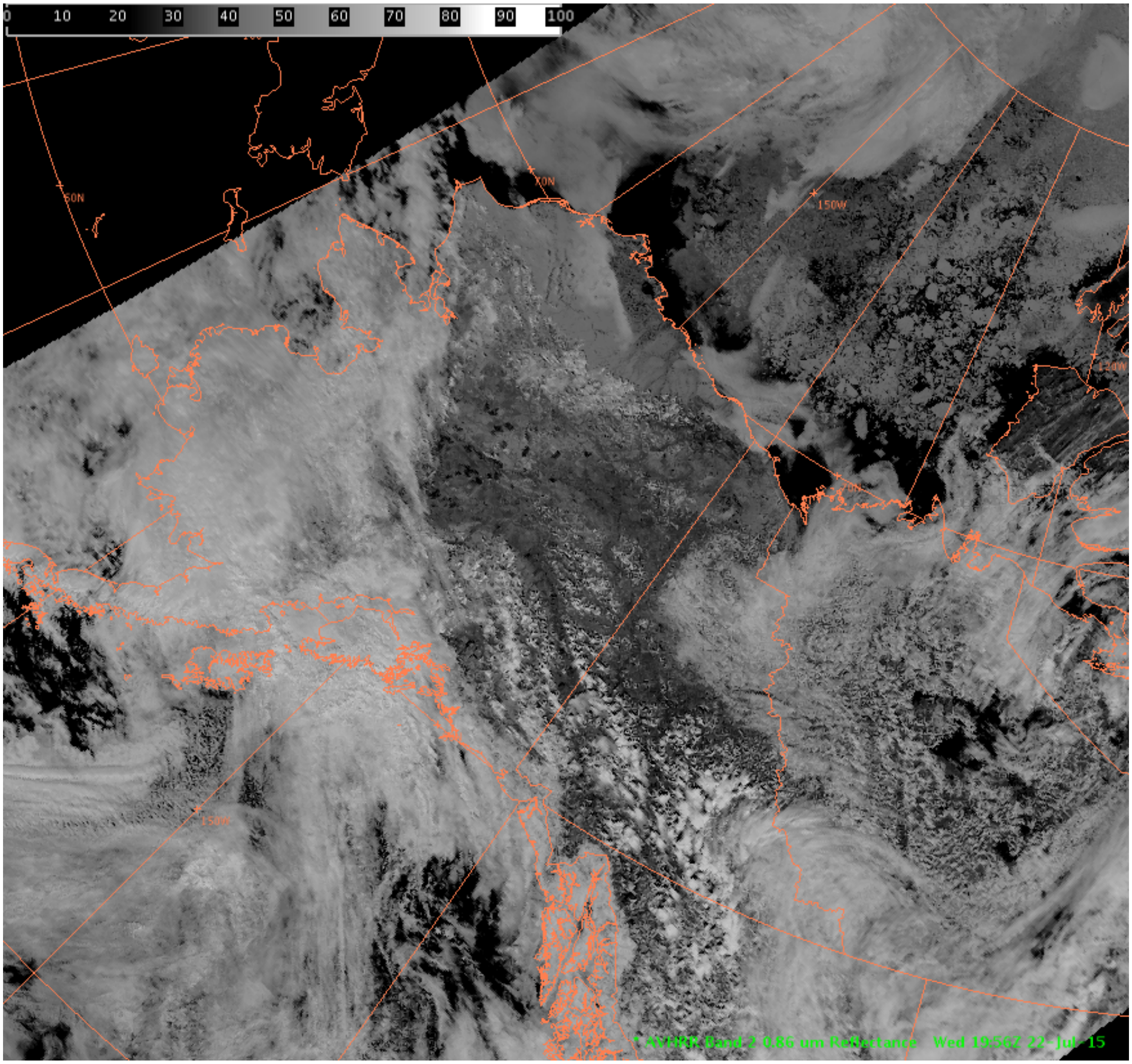
To verify your output file against the output file created at UW/SSEC, execute the following command:

```
cd ..
./p2g_compare_netcdf.sh output work_awips
```

This script compares the values of the NetCDF3 file with the benchmark file. The output from our test system is shown below. If you see similar output, the test was successful.

```
./p2g_compare_netcdf.sh output work_awips
Comparing work_awips/SSEC_AWIPS_metopb_avhrr_band2_vis_203_20150722_195652.nc to known valid file
SUCCESS: 0 pixels out of 60691776 pixels are different
All files passed
SUCCESS
```

A screen capture of the Metop-B AVHRR AWIPS NetCDF3 file, SSEC_AWIPS_metopb_avhrr_band2_vis_203_20150722_195652.nc, as displayed in AWIPS-II is shown below.



Section 7: Creating KMZ Files

Polar2grid Version 2.0 includes the capability to convert the GeoTIFF files that you created using any of the *gtiff.sh bash shell scripts into Keyhole Markup language Zipped (KMZ) files used for Google Earth displays. The simple implementation includes use of an existing Geospatial Data Abstraction Library (GDAL) command (gdal_translate), along with addition GDAL Python software to improve the quality of the output image.

The principal KMZ conversion script is `$POLAR2GRID_HOME/bin/gtiff2kmz.sh`, which operates by default in the current directory. The only required input is the path and GeoTIFF filename. Users can also specify an output file name; If no name is provided, the output KMZ filename will default to the GeoTIFF filename with the .tif suffix replaced by .kmz.

```
gtiff2kmz.sh
Usage: gtiff2kmz.sh input.tif [output.kmz]
```

`Input.tif` - Input GeoTIFF file and path created using Polar2Grid.
`[output.kmz]` - Optional output file name.

As an example, to create a Google Earth KMZ file from an input VIIRS Band 1 GeoTIFF file produced using viirs2gtiff.sh, you can execute a command like this:

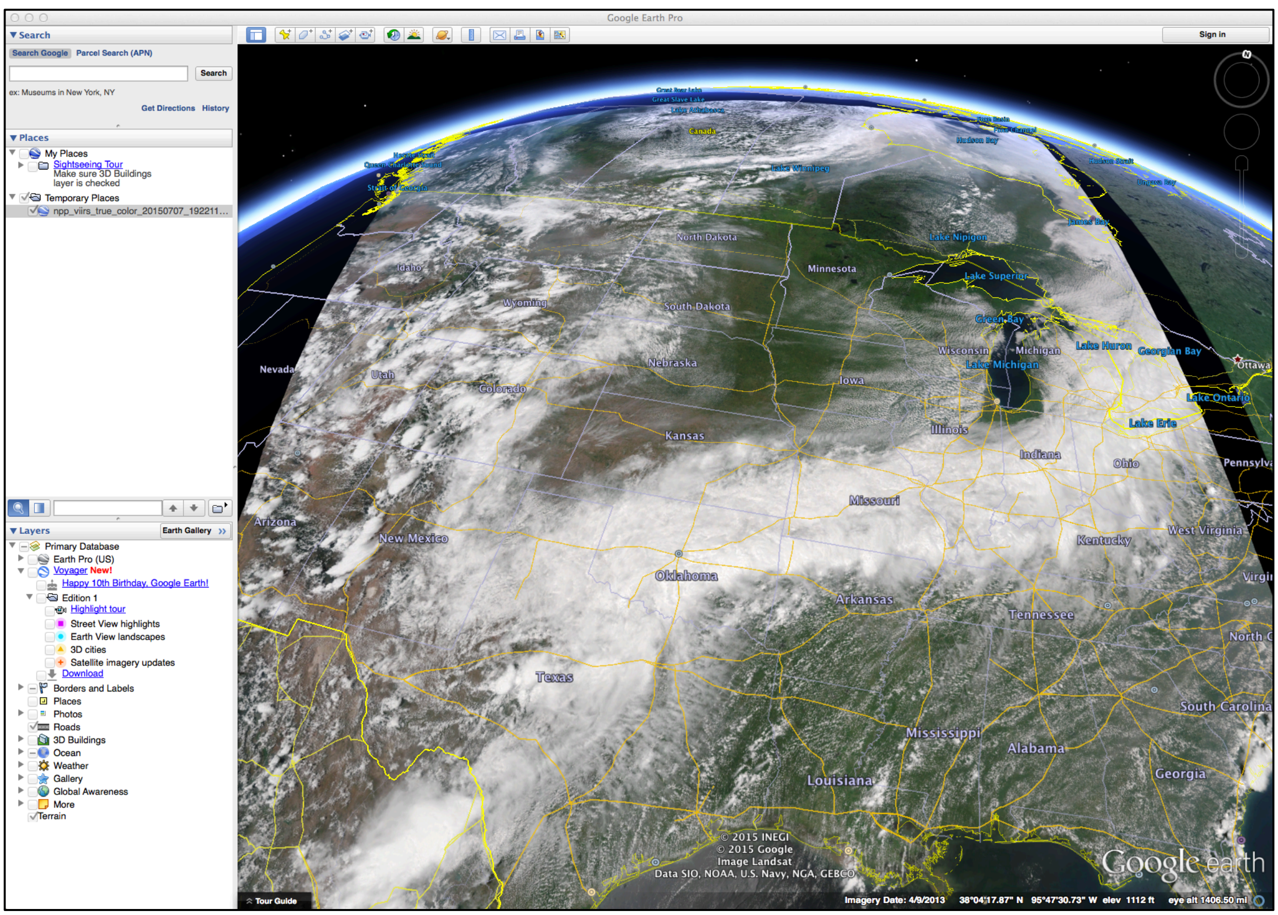
```
gtiff2kmz.sh /viirs/sdr/npp_viirs_viirs_crefl06_20150720_220842_wgs84_fit.tif
```

The software will provide details of its progress as it executes, and remove all intermediate files when it is finished.

If I wanted to rename the output kmz, I could use a command like this one,

```
gtiff2kmz.sh npp_viirs_true_color_20150707_192211_wgs84_fit.tif my_rgb.kmz
```

which converts the true color VIIRS GeoTIFF file created from a VIIRS overpass from 7 July 2015, into a KMZ file with the name “my_rgb.kmz”. A screen capture of the display of this file in Google Earth Pro is shown below.



Section 8: Image Scaling

8.1 Scaling Reflectance and Brightness Temperature Images

Data scaling for visible bands uses a simple square root enhancement. Scaling for brightness temperatures is done using a two pronged scaling based upon whether the temperature is greater or less than 242 degrees Kelvin. Please see the polar2grid rescaling website for more details:

http://www.ssec.wisc.edu/software/polar2grid/rescaling.html .

8.2 Scaling the VIIRS Day/Night Band Images

Scaling of the Day/Night Band is complicated due to the huge range of values that can exist across a given scene. The Day/Night Band is centered on .7 microns with a wide spectral response function (half width .505 to .890 microns). Polar2Grid Version 2.0 now offers the user three different options for enhancing the final image product. If no specific dnb enhancement is provided to the viirs2gtiff.sh or viirs2awips.sh scripts, three different output products will be created for the given scene. The three options are:

Histogram Day/Night Band scaling - option -p histogram_dnb
Adaptive Day/Night Band scaling - option -p adaptive_dnb
Dynamic Day/Night Band scaling - option -p dynamic_dnb

For the first two options, we have chosen to break up the radiance values and scale them based upon three regimes:

- Day – Solar zenith angles less than 88 degrees,
- Twilight or Terminator Region – Solar Zenith angles between 88 and 100 degrees, and
- Night – Solar Zenith Angles less than 100 degrees.

For each of these regions, a histogram equalization is calculated, excluding data that falls beyond 4 standard deviations of the mean. Then a histogram equalization is calculated across all the data in all of the regions. Then the data are scaled from 0-1, remapped to the requested projection and then finally rescaled to 0-255. This allows us to display day and night data together in one image, and make the maximum use of all of the data no matter how many regimes are included in a swath.

The figure below shows a polar2grid VIIRS Day/Night band image created using data that includes the transition region between day and night regimes. This data set was acquired on 22 June 2015.

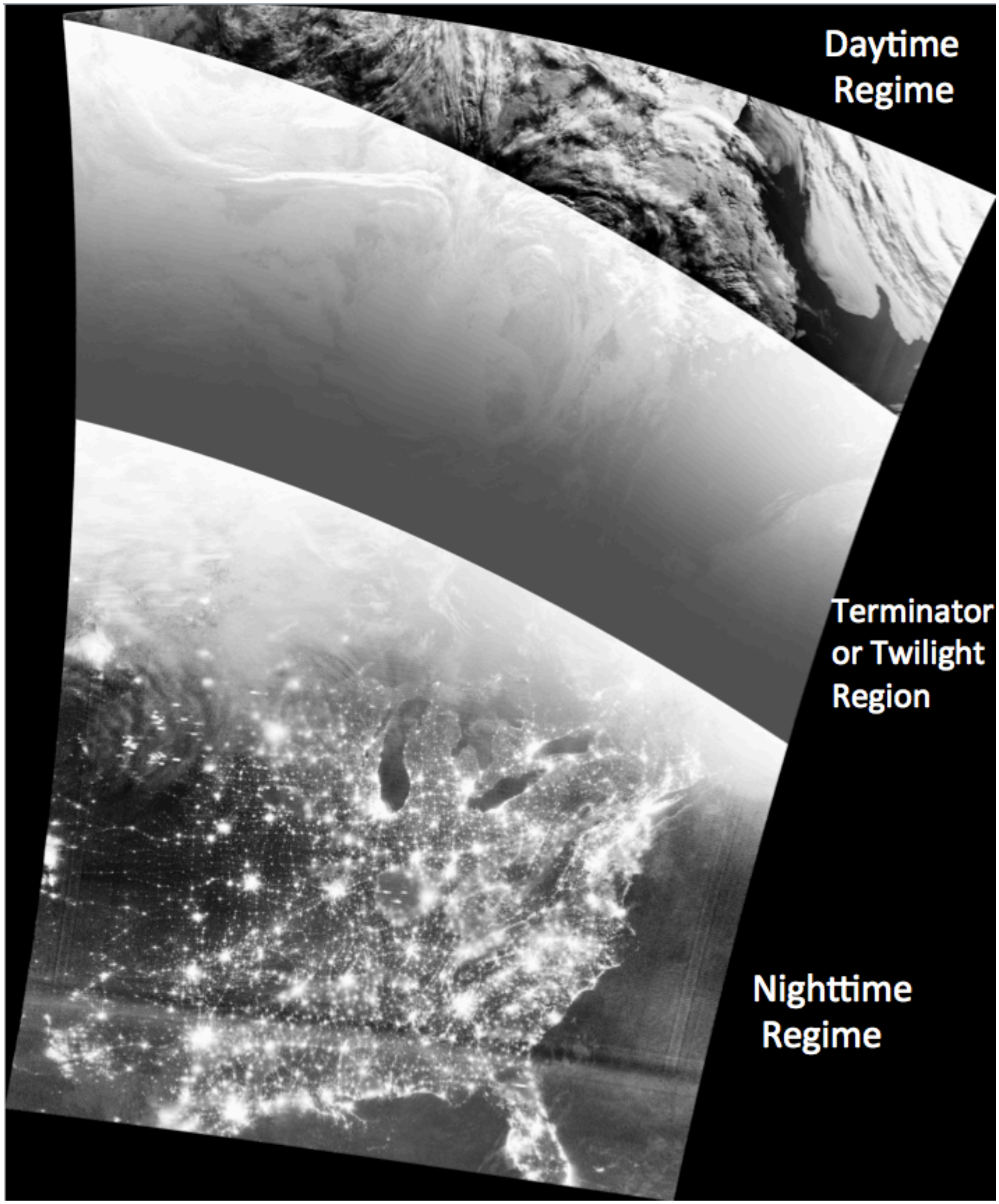


Image created from VIIRS Day/Night Band granules using the standard polar2grid enhancement scheme.

Option 2 is an alternative scaling that attempts to provide better contrast across the Terminator region of the Day/Night band. This algorithm cuts each region into tiles and calculates a histogram equalization for each tile. Once the histogram equalization functions have been calculated for each tile, each tile is processed separately. The "current tile" is equalized using the histogram equalization calculated from itself and it is also separately equalized using the surrounding tiles. These resulting equalized versions of the tiles are combined using bi-linear interpolation, so that each pixel uses a weighted amount in inverse relation to it's distance from the centers of the nearest 4 tiles. An example of the result of applying this technique to the same data set can be seen in the following image. Please note that some image artifacts (wave patterns) are introduced when applying this technique over the Terminator region. We continue our work to improve the display of the DNB in Terminator region

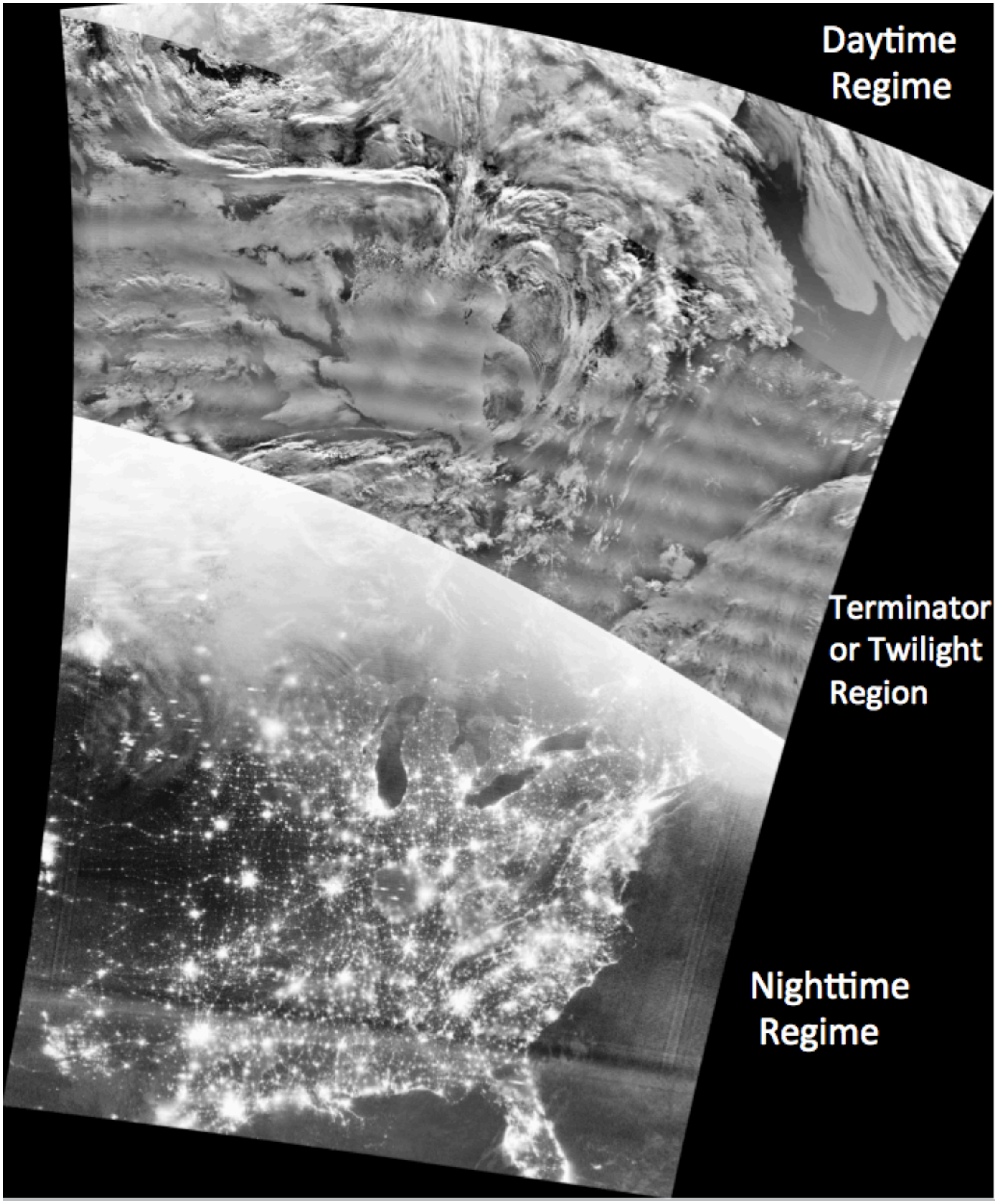


Image created from VIIRS Day/Night Band granules using the adaptive polarg2grid scaling enhancement in the terminator regions. The wavy patterns that can be seen in the image in this region are introduced by the enhancement algorithm.

A new option has been added in Polar2Grid Version 2.0 that implements an error function to scale the VIIRS Day/Night band data. This algorithm was provided by Dr. Curtis Seaman, NOAA Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University. For detailed information on this technique, please see:

Curtis J. Seaman, Steven D. Miller, 2015: A dynamic scaling algorithm for the optimized digital display of VIIRS Day/Night Band imagery. International Journal of Remote Sensing, Vol. 36, Iss. 7, pp. 1839-1854. DOI: 10.1080/01431161.2015.1029100.

The image below shows the result of executing viirs2gtiff.sh -p dynamic_dnb on our test dataset from 22 June 2015.

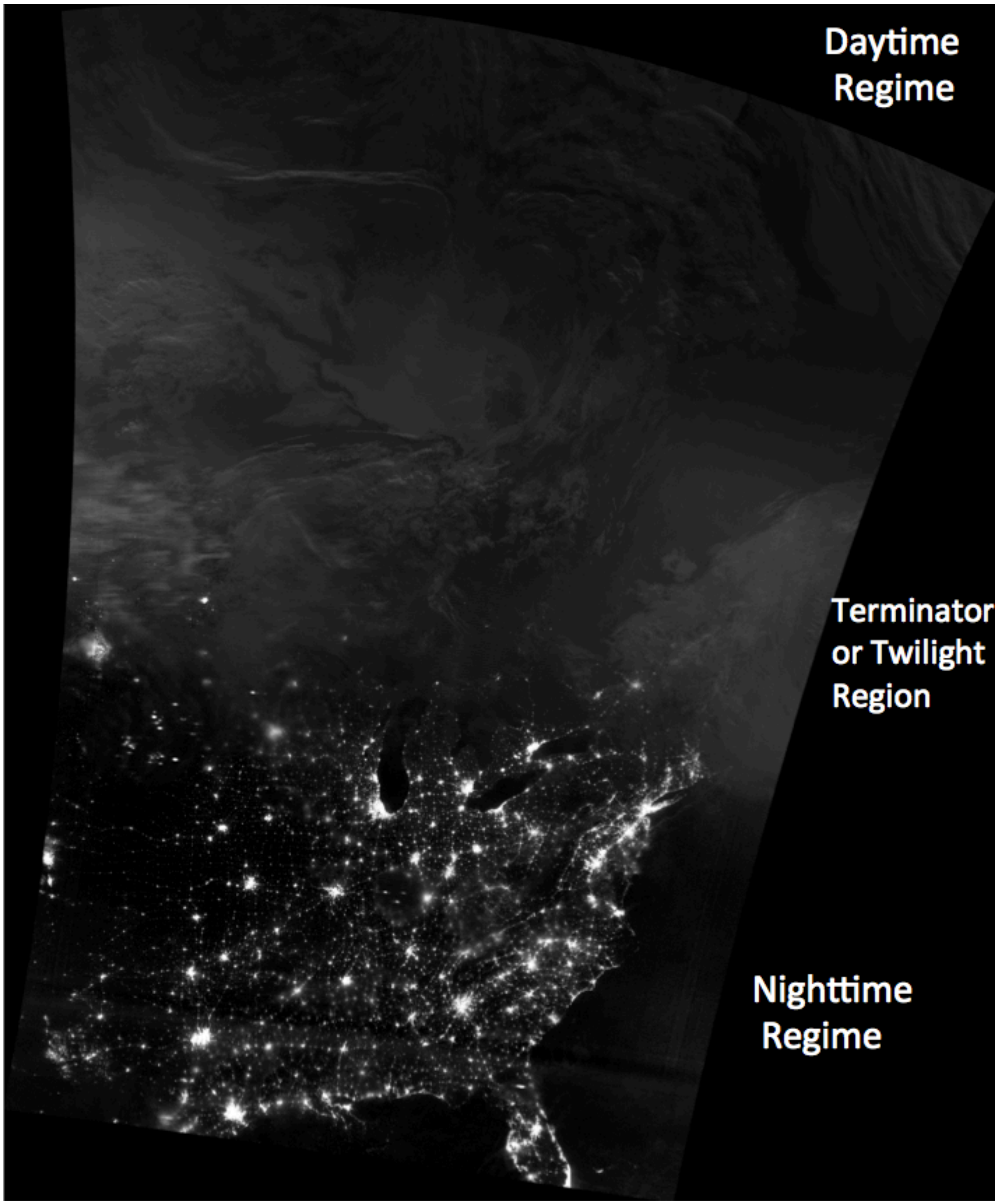


Image created from VIIRS Day/Night Band granules using the dynamic_dnb polarg2grid scaling enhancement.

Appendix 1: Creating your own grids

A1.1 Using the p2g_grid_helper Script

You can create reprojected image files over a domain and resolution that you specify by supplying a proj4 set of parameters in a grid configuration file. Proj4 is a library for performing conversions between cartographic projections (see http://proj.maptools.org/gen_parms.html). To help users with the correct configuration of the grid entry, a utility is available in polar2grid in which you supply the center longitude, latitude, spatial resolution, and number of lines and elements, and it will return a grid configuration entry. The output projection depends on the latitude that you provide:

Latitude < 15 degrees North or South - Equirectangular (Platte Carrée)
Latitude between 15 and 70 degrees North or South – Lambert Conic Conformal
Latitude > 70 degrees North or South – Stereographic

The utility is p2g_grid_helper.sh ($POLAR2GRID_HOME/bin):

```
p2g_grid_helper.sh  grid_name   center_longitude    center_latitude
pixel_size_x  pixel_size_y  grid_width  grid_height
```

where pixel size is in meters (m).

As an example, to create a 300m resolution GeoTIFF file centered on Madison, Wisconsin (43.1 N, -89.3 W), consisting of 1000x1000 grid elements, I would execute p2g_grid_helper.sh with these inputs:

```
p2g_grid_helper.sh madison_grid -89.3 43.1 300 300 1000 1000
```

Executing this script returns a proj4 string that can be used in a polar2grid configuration file:

madison_grid, proj4, +proj=lcc +datum=WGS84 +ellps=WGS84 +lat_0=43.100 +lat_1=43.100 +lon_0=-89.300 +units=m +no_defs, 1000, 1000, 300.000, -300.000, -91.184deg, 44.435deg

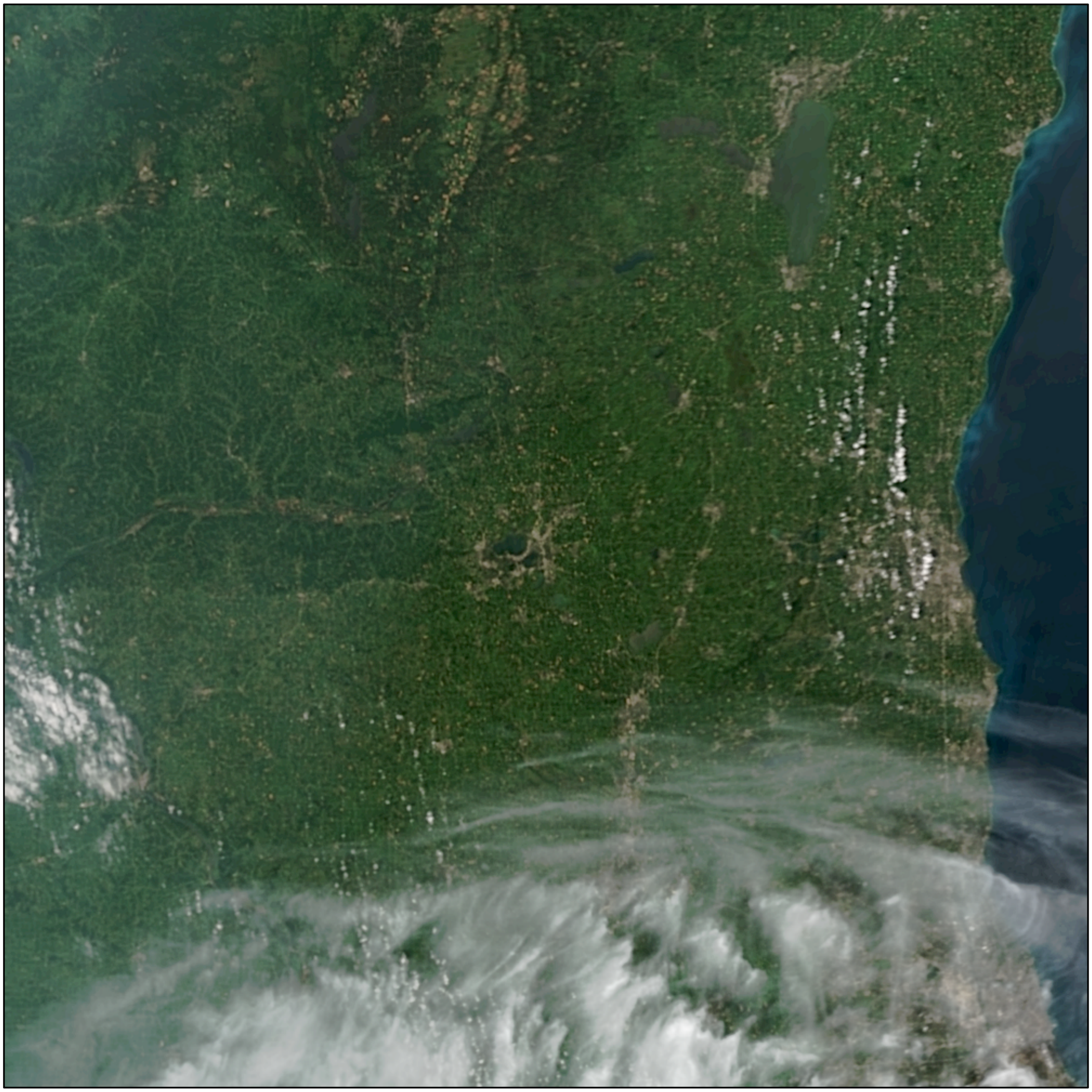
You can then create an ascii text configuration file and copy this line into it. There is a sample configuration file in polar2grid/grid_configs/grid_example.conf for reference. Once you have created a configuration file that contains at least 1 grid definition, you can reference both the config file, and the grid, and use it in any of the *gtiff.sh, *hdf5.sh, or *.bin.sh scripts. For example, I can create a configuration file called my_grid.conf, which contains my Madison, Wisconsin grid proj4 definition. I can now create an image by executing a command like this:

```
viirs2gtiff.sh --grid-configs ${HOME}/my_grid.conf -g madison_grid -f
${HOME}/polar2grid/test_night_data
```

This command will create GeoTIFF files using all of the VIIRS SVI, SVM and DNB h5 files found in the ${HOME}/polar2grid/test_night_data directory, as long as the VIIRS Geolocation files are also found there. I can also now create a true color image by executing a similar command on a daytime pass:

```
crefl2gtiff.sh --grid-configs ${HOME}/my_grid.conf -g madison_grid -f
${HOME}/crefl/test_day_data
```

Executing this command will first create CREFL HDF4 files from the SV*.h5 files found in `${HOME}/crefl/test_day_data` and then use those files to create a true color 24 bit GeoTIFF file. The result of this execution for a VIIRS overpass collected on 22 August 2015, 18:18 UTC is displayed below.



Similarly, I can also create MODIS reprojections using my grid configuration.

```
modis2gtiff.sh -p vis01 vis07 bt31 --grid-configs ${HOME}/my_grid.conf -g
madison_grid -f ${HOME}/test_data/t1.15239.1721.{1000m,geo}.hdf
```

will create output MODIS geotiff files of bands 1, 7 and 31 from the Terra 1km HDF4 L1B file (t1.15239.1721.1000m.hdf) found in the ${HOME}/test_data directory. And finally, executing this command:

```
crefl2gtiff.sh --grid-configs ${HOME}/my_grid.conf -g madison_grid -f
${HOME}/test_data/t1.15239.1721.{1000m,500m,250m,geo}.hdf
```

will create an output MODIS 24 bit true color image of the madison grid region using the Terra 1km HDF4 L1B file (t1.15239.1721.1000m.hdf) sharpened by the 250m file found in the ${HOME}/test_data directory. All three MODIS file resolutions are required in order to create the corrected reflectance files that are used by Polar2Grid.