

MODIS LEVEL 2 PRODUCT SOFTWARE PACKAGE FOR DIRECT BROADCAST

Beta Version 3.1

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This package contains the software needed to process Aqua and Terra MODIS Level 1B direct broadcast (DB) or archived data files into MODIS Level 2 Collect 6 cloud mask (MOD35), cloud top properties and cloud phase (MOD06CT), cloud optical properties (MOD06OD), atmospheric profiles (MOD07), aerosol (MOD04), sea surface temperatures, near infrared total column water vapor, snow mask, ice surface temperature, ice cover and ice concentration and polar inversion depth and strength in HDF4 format. This software has been packaged to run as one inline set of executables called from a single shell script (imapp_modisl2/scripts/modis_level2.sh).



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CHANGES SINCE V3.0 RELEASE

MODIS MOD06 Cloud Optical Properties Collection 6

The MODIS Level 2 Collection 6 cloud optical properties (MOD06OD) product software is now included with this release of IMAPP MODIS Level 2. It requires as input the MOD06 cloud top (MOD06CT) product file that is also created as part of this software distribution. The direct broadcast near real-time output files will create output that will be close to but not identical to the official archived products because some of the required dynamic ancillary files are not available until well after real-time. In addition, to reduce the size of the release, a year of global monthly averaged static input albedo files are used as input as opposed to the standard 8 day albedo files used to generate the official archived NASA products. These albedo files are still very large. The total size of the coefficient/albedo files required for MOD06OD processing is about 30GB.

New Terra destriping configuration file

A new configuration file for destriping Terra L1B files is included for use with data after 2008-06-27. The file uses new reference detectors for MODIS bands 25, 27 and 36. The run_modis_destripe.sh script automatically chooses the correct configuration file version to use with the data.

QUICK GUIDE TO RUNNING THE IMAPP MODIS LEVEL 2 PRODUCT SOFTWARE

More detailed instructions are available following this section. The software should work on most flavors of 64 bit Linux operating systems.

1) Download the beta package from the IMAPP beta ftp site:

<ftp://ftp.ssec.wisc.edu/pub/IMAPP/beta/modisl2/>

Download and unpack the required IMAPP_MODISL2_V3.1.tar.gz file, the MOD04 Aerosol coefficient files, IMAPP_MODISL2_V3.1_MOD04_COEFF.tar.gz, and the LEOCAT static support files (required for MOD35 Cloud Mask and MOD06CT Cloud Top Property product creation), IMAPP_MODISL2_V3.1_LEOCAT_COEFF.tar.gz. Please note that the coefficient files for the MOD04 product are almost 10GB in size and the LEOCAT dataset is about 13GB in size.

If you would like to run the MOD06OD Cloud Optical Property algorithm, the MOD06OD coefficient files also need to be downloaded. They include IMAPP_MODISL2_V3.1_MOD06OD_COEFF.tar.gz, IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_1.tar.gz, and IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_2.tar.gz, which unpack to be 27GB in size.

In this example, we unpack the main package into \$HOME

```
cd $HOME
tar zxvf IMAPP_MODISL2_V3.1.tar.gz
```

Once this has been done, unpack the MOD04 coefficient file and the LEOCAT coefficient file from the same directory (both may take several minutes to unpack), for example:

```
cd $HOME
tar zxvf IMAPP_MODISL2_V3.1_LEOCAT_COEFF.tar.gz
tar zxvf IMAPP_MODISL2_V3.1_MOD04_COEFF.tar.gz
```

This will place the MOD04 coefficients into the imapp_modisl2/src/aerosol/coeff directory and the LEOCAT static data files into the imapp_modisl2/src/leocat/coeff directory.

If running MOD06OD, also unpack the MOD06OD coefficient files from the same directory:

```
tar zxvf IMAPP_MODISL2_V3.1_MOD06OD_COEFF.tar.gz
tar zxvf IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_1.tar.gz
tar zxvf IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_2.tar.gz
```

The MOD06OD coefficients will be placed in the imapp_modisl2/src/cloudoptical/coeff directory. The MOD06OD algorithm will not run if those coefficient files are not found.

2) OPTIONAL: Download the input/output test data set and unpack.

In this example case, we will copy the test input data into the /imapp_modisl2/input_data directory. When you unpack the test input/output file, it will create a main IMAPP_MODISL2_V3.1_INPUT_OUTPUT directory along with a test_input, test_output, and images sub-directories.

```
cd $HOME
tar zxvf IMAPP_MODISL2_V3.1_INPUT_OUTPUT.tar.gz
cd IMAPP_MODISL2_V3.1_INPUT_OUTPUT/test_input
cp *.hdf ../../imapp_modisl2/input_data
```

Required inputs are MODIS L1B Aqua or Terra 1 km, 500m, 250m and geolocation files for daytime processing and MODIS L1B Aqua or Terra 1km and geolocation files for nighttime processing. One set of input files is included in the input_output test data set package. All input files should be placed in the same directory.

3) Set environment variables in the environment script

The variable setting script for a bash environment is located in the /imapp_modisl2/env directory (**imapp_modisl2.bash_env**). Set the MODIS_L2_HOME environment variable to the name of the directory where the IMAPP MODIS L2 software was installed (\$HOME in this example).

```
export MODIS_L2_HOME=$HOME/imapp_modisl2
```

You can also edit this script to customize your installation, including setting the local and remote ancillary data locations, as well as limiting the search for ancillary data to the local machine (don't try downloading from an external site). Once the variables have been set, then execute the environment setting script as shown below:

```
source $MODIS_L2_HOME/env/imapp_modisl2.bash_env
```

This will allow access to the imapp_modisl2 scripts and executables through your \$PATH.

4) Create MODIS Level 2 products by running the main processing script from any directory, modis_level2.sh:

Usage: modis_level2.sh [Options] L1BFILE OUTDIR [TMPDIR]

Where:

[Options] - These flags are optional. Default is to run all IMAPP product executables, and for the temporary run directory to remain upon completion.

- nocloudmask - do not run cloudmask
- nosst - do not run sst
- nocloudtop - do not run cloudtop properties
- nocloudopt - do not run cloud optical properties
- nopfiles - do not run profiles
- noaerosol - do not run aerosols
- nowvnir - do not run wvnir
- noist - do not run ice surface temperature
- nonsi - do not run snow mask
- noicec - do not run ice concentration
- noinv - do not run temperature inversion software
- noreagg - do not re-aggregate L1B data before creating products
- noquicklook - do not run quicklook plotting script
- compress - Internally compress output product files (uses hrepack)
- deltmp - delete temporary directory when complete

L1BFILE - Level-1B 1KM file

OUTDIR - output file directory

TMPDIR - [Optional] Name of temporary directory to create or re-use for flat files. Default is date-based name.

So for our example, we choose to run all of the algorithms, use the default temporary run directory, and place the output files into the \$MODIS_L2_HOME/products directory:

```
modis_level2.sh \  
$MODIS_L2_HOME/input_data/a1.14063.1450.1000m.hdf \  
$MODIS_L2_HOME/products
```

A temporary directory will be created in the current directory where all intermediate files are created and execution takes place. In our example, this directory name will be: 2014063_Aqua_1450_hhmmss, where hhmmss is the hh-hour, mm-minute and ss-second that the package was executed.

As another example, if you did not want to create an sst product and you wanted to delete the temporary directory after the processing was finished, you would type:

```
modis_level2.sh -nosst -deltmp \  
$MODIS_L2_HOME/input_data/a1.14063.1450.1000m.hdf \  
$MODIS_L2_HOME/products
```

5) If you choose to create quicklooks of the products, the images will be placed in the \$MODIS_L2_HOME/images directory.

The directory location can be customized through the environmental variable MODIS_L2_IMAGES.

6) Required ancillary data files are fetched automatically from the IMAPP ancillary ftp site.

You can set the place to look for ancillary data locally and where to look for it externally in the env script. In our test case, it will fetch the data from the IMAPP ancillary archive ftp site and download it into the \$MODIS_L2_HOME/ancillary directory (these are the env script defaults). The ancillary data directories that are created upon download are not deleted upon completion. You must delete the directories and files within them if you do not wish to archive them.

1.0 INTRODUCTION

(1.1) System requirements

(a) The software is supported on the following Linux operating systems using the gfortran gnu (gcc 4.4.7) compiler:

```
Red Hat Enterprise Linux 5.9 x86_64  
CentOS 5.10 and 6.5 x86_64
```

The binaries have been statically linked, and should work on most 64 bit Linux OS/platforms.

(b) This release requires about 90 GB of disk space to install the software, the supporting ancillary data files, the input/output test data sets and the intermediate files created during runtime.

(c) Execution of the software will require ~1GB of memory.

(1.2) Software requirements

(a) All software required to create the IMAPP MODIS L2 science products and scripts for fetching ancillary data are included with this release, with the exception of the wget utility. Required binaries include hdp, hrepack, ncdump, wgrib and a date/time utility dateplus.exe. All of these are located within the /imapp_modisl2/bin directory. All have been compiled statically and tested on the supported platforms. If you get an error message when executing hdp or ncdump, these utilities are a part of the hdf distribution, and pre-compiled binaries can be acquired from:

<http://www.hdfgroup.org/release4/obtain.html>

Finally, wgrib, the utility to unpack fields from the ancillary GRIB files can be acquired from:

<http://www.cpc.ncep.noaa.gov/products/wesley/wgrib.html>

(b) A configuration script which sets the correct environmental variables for your computer platforms/OS is included in the /imapp_modisl2/env directory. The bash shell is supported. The path to the main directory (MODIS_L2_HOME) must be set prior to the execution of the run scripts.

(c) Statically pre-compiled versions of the science product executables are included within the /imapp_modisl2/bin directory. The imapp_modisl2/scripts/Build.sh and Clean.sh scripts can be used to recompile the code for most of the programs. The individual make files located within the main source directory for each program can also be used to compile the code.

(1.3) Input data requirements

(a) MODIS Level 1B data

All of the IMAPP MODIS Level 2 products require the MODIS 1km Level 1B and geolocation files as input. The MODIS cloud mask and aerosol products use the 250 m file as input and the aerosol product also requires the MODIS 500 m file as input. The software uses input L1B files with the t1 and a1 direct broadcast naming conventions or the MODIS Archive L1B files with the MYD and MOD naming conventions.

For example, the standard MODIS Archive L1B 1km files are named:

(Prefix MYD-aqua, MOD-terra, yyyy-year, ddd-Julian Day, hh-hour, mm-minute)

MYD021KM.Ayyyyddd.hhmm.xxxxxxxxxxxxxx.hdf	1 km
MYD02HKM.Ayyyyddd.hhmm.xxxxxxxxxxxxxx.hdf	500 m
MYD02QKM.Ayyyyddd.hhmm.xxxxxxxxxxxxxx.hdf	250 m
MYD03.Ayyyyddd.hhmm.xxxxxxxxxxxxxx.hdf	geolocation

and the standard IMAPP Level 1B files are named:
(Prefix a1-aqua, t1-terra, yy-year last 2 digits, ddd-Julian Day, hh-hour, mm-minute)

a1.yyddddd.hhmm.1000m.hdf	1 km
a1.yyddddd.hhmm.500m.hdf	500 m
a1.yyddddd.hhmm.250m.hdf	250 m
a1.yyddddd.hhmm.geo.hdf	geolocation

(b) Ancillary data

Static ancillary data files are located within the individual /src directories. Dynamic required ancillary data files are identified and fetched automatically within the product run scripts. Please see the: <ftp://ftp.ssec.wisc.edu/pub/eosdb/ancillary/00README Ancillary.txt> file for more information on ancillary data. Remote and local ancillary data locations must be set prior to MODIS L2 script execution. These are set within the environmental variable script located in the /imapp_modisl2/env directory.

2.0 PACKAGE DETAILS

This package produces Level 2 MODIS products in HDF format. The standard MODIS products are created using the same software as the official MODIS HDF products created at the MODIS Adaptive Processing System (MODAPS) and distributed through the Level 1 and Atmospheres Archive and Distribution System (LAADS).

The main script included with this release will run all of the executables in sequence and copy the output files to the destination directory specified in an argument to the main run script, modis_level2.sh.

The IMAPP MODIS Level 2 package is distributed under the GNU GENERAL PUBLIC LICENSE agreement that is included with this release. In addition, this disclaimer applies to all parts of this release:

DISCLAIMER

The University of Wisconsin-Madison Space Science and Engineering Center (SSEC) makes no warranty of any kind with regard to the IMAPP MODIS Level 2 software or any accompanying documentation, including but not limited to the implied warranties of merchantability and fitness for a particular purpose. SSEC does not indemnify any infringement of copyright, patent, or trademark through the use or modification of this software.

There is no expressed or implied warranty made to anyone as to the suitability of this software for any purpose. All risk of use is assumed by the user. Users agree not to hold SSEC, the University of Wisconsin-Madison, or any of its employees or assigns liable for any consequences resulting from the use of the IMAPP MODIS Level 3.1 software.

3.0 PACKAGE CONTENTS

The distribution package consists of the following files:

Name	Size (bytes)	Unpacked	Compressed
00README_IMAPP_MODIS_LEVEL2_V3.1.pdf			
IMAPP_MODISL2_V3.1.tar.gz		4.0 GB	1.0 GB
IMAPP_MODISL2_V3.1_LEOCAT_COEFF.tar.gz		13 GB	1.9 GB
IMAPP_MODISL2_V3.1_MOD04_COEFF.tar.gz		9.4 GB	2.4 GB
IMAPP_MODISL2_V3.1_MOD06OD_COEFF.tar.gz		5.0 GB	8.6 GB
IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_1.tar.gz		8.9 GB	9.1 GB
IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_2.tar.gz		8.8 GB	8.9 GB
IMAPP_MODISL2_V3.1_INPUT_OUTPUT.tar.gz		944 MB	565 MB

00README_IMAPP_MODIS_LEVEL2_V3.1.pdf contains documentation on the IMAPP MODIS direct broadcast Level 2 release.

IMAPP_MODISL2_V3.1.tar.gz contains statically compiled binary executables, source code, run scripts, coefficient files, environmental variable scripts, static ancillary files and configuration files for Linux platforms. This is a required file.

IMAPP_MODISL2_V3.1_LEOCAT_COEFF.tar.gz contains data files that are required to run the LEOCAT algorithms within the MODIS cloud mask (MOD35) and cloud top (MOD06CT) software.

IMAPP_MODISL2_V3.1_MOD04_COEFF.tar.gz contains coefficient files that are required to run the MODIS aerosol software (MOD04).

IMAPP_MODISL2_V3.1_MOD06OD_COEFF.tar.gz contains coefficient files that are required to run the MODIS cloud optical property software (MOD06OD).

IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_1.tar.gz contains half of the surface albedo files required to run the MODIS cloud optical property software (MOD06OD).

IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_2.tar.gz contains the other half of the surface albedo files required to run the MODIS cloud optical property software (MOD06OD).

IMAPP_MODISL2_V3.1_INPUT_OUTPUT.tar.gz contains sample input/output data files. These files are required to verify the installation of the package.

NOTE: There are dynamic ancillary data files that are required in order to run the software. They are included in the package but not needed unless you wish to place them in your local ancillary data directory. Scripts which automatically fetch the files from the IMAPP ancillary data archive are provided and execute automatically within the product run scripts.

4.0 INSTALLATION

The IMAPP MODIS Level 2 Beta Version 3.1 direct broadcast package is distributed through the IMAPP ftp site:

<ftp://ftp.ssec.wisc.edu/pub/IMAPP/beta/modisl2/>

(4.1) Download the files

Get the files described in section 3.0.

(4.2) Unpack the files

Go to the directory where you want the software to be installed, and then unpack the software package, e.g.,

```
cd $HOME
tar zxvf IMAPP_MODISL2_V3.1.tar.gz
```

A new directory named 'imapp_modisl2' containing the software package will be created, along with these subdirectories:

/ancillary – Default directory for your local ancillary data archive.

/bin – Contains static binary files used in product generation.

/config – Contains individual product default configuration files.

These will be filled with input/output file names upon execution.

/doc – Contains ASCII text output product file descriptions:

- Aerosol_Output_Description.txt
- Cloud_Mask_Bit_Description.txt
- Cloud_Top_Property_Output_Description.txt
- Flatfile_Output_Description.txt
- Ice_Cover_Concentration_Output_Description.txt
- Ice_Cover_Concentration.pdf
- IST_Output_Description.txt
- Polar_Inversion_Output_Description.txt
- Profiles_Output_Description.txt
- Snow_Mask_Output_Description.txt
- SST_Output_Description.txt
- WVNIR_Output_Description.txt

/env – Contains file to source to set environmental variables.

(imapp_modisl2.bash_env)

This sets the following variables - shown here with the default paths:

MODIS_L2_HOME= *(set this to the package home directory)*

LOCAL Anc DIR= $\$MODIS_L2_HOME/ancillary$ *(path to local ancillary repository)*

REMOTE Anc DIR= $ftp://ftp.ssec.wisc.edu/pub/eosdb/ancillary$ *(site of remote ancillary data directory)*

MODIS_L2_CFG= $\$MODIS_L2_HOME/config$ *(location of config files)*

MODIS_L2_BIN=\$MODIS_L2_HOME/bin (*location of executables*)
MODIS_L2_IMAGES=\$MODIS_L2_HOME/images (*path to output images*)
OUTPUT_TYPE=2 (*output product format where: 1 = binary only, 2 = hdf only, 3 = binary and hdf*)
MODIS_L2_RES=3 (*output image resolution*)
PGSHOME= \$MODIS_L2_HOME/toolkits/TOOLKIT_gfortran_f90 (*path to SDP toolkit directory*)
PGSMMSG= \$PGSHOME/message (*path to SDP toolkit message files*)
PGSINC= \$PGSHOME/include (*path to SDP toolkit include files*)
PGSLIB= \$PGSHOME/lib/linux (*path to SDP toolkit libraries*)
PATH=./\$MODIS_L2_BIN:\$MODIS_L2_HOME/scripts:\$PGSHOME
 :\$PGSMMSG:\$PATH
 (*Adds /bin and /script and SDP toolkit directories to your \$PATH*)
API_HOME=\$MODIS_L2_HOME/toolkits/mapi6.0.1 (*path to M-API toolkit directory*)
API_INC=\$API_HOME/h (*path to M-API include files*)
API_LIB=\$API_HOME/lib (*path to M-API libraries*)
API_SRC= \$API_HOME/srclib (*path to M-API source files*)
HDF5LIB= \$PGSHOME/hdf5/linux/hdf5-1.8.8/lib (*location of HDF5 libraries*)
LD_LIBRARY_PATH=\$HDF5LIB (*location of dynamic shared libraries*)
DOWNLOAD_ANC=true
 Set to false to keep the script from downloading ancillary data from external sites.
http_proxy=http://username:password@foo.bar:8080
 Set http_proxy if you are using a proxy server. This will allow you to use the automated ancillary data fetching scripts. The example above shows how it would be set if you need to include a username and password.

/input_data – empty - you can use this directory to place the L1B input test files.

/products – empty - the test run script can be used to place the output products here.

/scripts – Contains the scripts which run the ancillary data fetchers, the main modisl2 script (modis_level2.sh) and individual product run scripts (i.e., run_modis_cloudmask.sh).

/ShellB3 – Contains python modules needed for creating quicklook images.

/src – Contains the source code, include files, static ancillary files and make files for each MODIS product.

Source code included in this release:

flatfile – Software to extract MODIS L1B data into binary flatfiles, the native IMAPP format used as input to some science data product software, including the cloud mask.

destripe – Software to destripe L1B file.

cloudmask – Collect 6 MODIS cloud mask software (MOD35).

aerosol – Collect 6 MODIS aerosol MOD04 product software. Uses MODIS cloud mask and profile files as inputs.

cloudtop – Collect 6 MODIS cloud top properties software (MOD06CT). Uses MODIS cloud mask file as input.

cloudoptical – Collect 6 MODIS cloud optical properties software. Uses MODIS cloud mask as input.

leocat – LEOCAT software used in MOD35 and MOD06 processing.

profiles – Collect 6 MODIS profiles software (MOD07). Uses MODIS cloud mask file as input.

sst – UW SSEC Sea Surface Temperature software.

wvnir – UW SSEC Near infrared water vapor software.

dateplus – date utility - used by product run scripts.

Polar Products

ice_concentration – UW SSEC polar ice mask and polar ice concentration software.

ice_surface_temperature – UW SSEC polar ice surface temperature software.

inversions – UW SSEC polar inversion strength and inversion depth software.

snow_mask – UW SSEC polar snow mask software.

/toolkits – Contains MODIS Application Program Interface (M-API) and SDP toolkit libraries and include files needed in support of the software.

(4.3) Set the required environmental variables

Set the MODIS_L2_HOME environment variable to the name of the directory where the IMAPP MODIS L2 package was installed (\$HOME in this example).

```
export MODIS_L2_HOME=$HOME/imapp_modisl2
```

Set any other environmental variables as needed for your processing environment by editing the imapp_modisl2/env/imapp_modisl2.bash_env file. You can make changes to options such as the LOCAL_ANC_DIR (the directory on your local machine that you would like to check for ancillary data), the REMOTE_ANC_DIR (the place to look for the ancillary data remotely) and limit the ancillary data search to the local directory only (don't allow external downloads). The default location for the remote ancillary site is the IMAPP ftp site:

<ftp://ftp.ssec.wisc.edu/pub/eosdb/ancillary>

It should be noted that the automated scripts will look for ancillary data in a directory structure that is similar to that found on the IMAPP ancillary data ftp site, i.e. LOCAL_ANC_DIR/yyyy_mm_dd_ddd .

Once you have set the MODIS_L2_HOME and made any changes you want to the environmental script, then execute the script to set all of the variables.

```
source $MODIS_L2_HOME/env/imapp_modisl2.bash_env
```

Sourcing this script will set those environmental variables and add the /bin, /scripts, python, and toolkit directories to your \$PATH.

(4.4) Update the utility leapsec and utcpole files

Run the update_leapsec_utcpole.sh script in the imapp_modisl2/scripts directory to update the leapsec.dat and utcpole.dat files. NOTE: if those files are not up-to-date, the software will fail. These files are automatically updated if their timestamp is more than 7 days old when the software requiring them is executed.

(4.5) If not running on linux OS, compile the software

If you are not going to use the pre-compiled binaries located in the /bin directory, you will need to compile the code manually. If you wish to compile the code yourself, cd into the individual product src or cmd directory and type "make" and

copy the executable into the /bin directory. The scripts are set up to try and compile on Linux operating systems. Note: For other than the supported platforms, you will need to get the correct versions of the files in the /bin directory for your platform/OS. See section 1.0, software requirements. The executables and test output products were all created on a little endian platform.

(4.6) Download the Coefficient files for MOD35, MOD06CT, MOD04, and MOD06OD creation

Download and unpack the LEOCAT (for Cloud Mask (MOD35) and Cloud Top Properties (MOD06CT)) and aerosol (MOD04) coefficient files, IMAPP_MODISL2_V3.1_LEOCAT_COEFF.tar.gz and IMAPP_MODISL2_V3.1_MOD04_COEFF.tar.gz respectively, from the ftp site. Please note that the unpacked LEOCAT and MOD04 coefficient files are almost 22.4 GB in size.

If you would like to run the MOD06OD Cloud Optical Property algorithm, the MOD06OD coefficient files also need to be downloaded. They include IMAPP_MODISL2_V3.1_MOD06OD_COEFF.tar.gz, IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_1.tar.gz, and IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_2.tar.gz, which unpack to be 27GB total.

Unpack the files from the same directory that you unpacked the IMAPP MODISL2_V3.1.tar.gz file:

```
cd $MODIS_L2_HOME/..
tar zxvf IMAPP_MODISL2_V3.1_LEOCAT_COEFF.tar.gz
tar zxvf IMAPP_MODISL2_V3.1_MOD04_COEFF.tar.gz
tar zxvf IMAPP_MODISL2_V3.1_MOD06OD_COEFF.tar.gz
```

This will place the LEOCAT coefficients into the imapp_modisl2/src/leocat/coeff directory and the MOD04 coefficients into the imapp_modisl2/src/aerosol/coeff directory.

If running MOD06OD, unpack the MOD06OD coefficient files from the same directory:

```
tar zxvf IMAPP_MODISL2_V3.1_MOD06OD_COEFF.tar.gz
```



```
tar zxvf IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_1.tar.gz
tar zxvf IMAPP_MODISL2_V3.1_MOD06OD_COEFF_ALBEDOMAPS_2.tar.gz
```

The MOD06OD coefficients will be placed in the `imapp_modisl2/src/cloudoptical/coeff` directory. The MOD06OD algorithm will not run if those coefficient files are not found.

(4.7) Run the software

As long as you have set the correct directory for `MODIS_L2_HOME` in the environmental variables source script, and sourced it, you can now execute the run script from any directory, however you must have all of the L1B input files (1km, 500m, 250m and geolocation) located within the same directory. To create the products type:

```
modis_level2.sh [Options] L1BFILE OUTDIR [TMPDIR]
```

Usage: `modis_level2.sh [Options] L1BFILE OUTDIR [TMPDIR]`

Where:

[Options] - These flags are optional. Default is to run all IMAPP product executables, and for the temporary run directory to remain upon completion.

<code>-nocloudmask</code>	- do not run cloudmask
<code>-nosst</code>	- do not run sst
<code>-nocloudtop</code>	- do not run cloudtop properties
<code>-nocloudopt</code>	- do not run cloud optical properties
<code>-noprofiles</code>	- do not run profiles
<code>-noaerosol</code>	- do not run aerosols
<code>-nowvnir</code>	- do not run wvnir
<code>-noist</code>	- do not run ice surface temperature
<code>-nonsi</code>	- do not run snow mask
<code>-noicec</code>	- do not run ice concentration
<code>-noinv</code>	- do not run temperature inversion software
<code>-noreagg</code>	- do not re-aggregate L1B data before creating products
<code>-noquicklook</code>	- do not run quicklook plotting script
<code>-compress</code>	- Internally compress output product files (uses hrepack) default is to not compress files
<code>-deltmp</code>	- delete temporary directory when complete

L1BFILE - Level-1B 1KM file
OUTDIR - output file directory
TMPDIR - [Optional] Name of temporary directory to create or re-use for flat files. Default is date-based name.

The output files that are moved to the output directory upon completion depend upon the output type that you have chosen. If you choose to produce both binary and hdf files (see OUTPUT_TYPE environment variable) for the SST, WVNIR, and polar products, then the files moved will be:

(Where: s=t for terra or a for aqua, yy=year-2000, ddd=Julian Day, hh=hour, mm=minute taken from the direct broadcast MODIS 1km L1B file)

s1.yyddd.hhmm.mod35.hdf	- Cloud mask HDF file
s1.yyddd.hhmm.mask_byte1.hdf	- Cloud mask first byte only HDF file
s1.yyddd.hhmm.mod04.hdf	- Atmospheric aerosol HDF file
s1.yyddd.hhmm.mod04_3k.hdf	- Atmospheric aerosol 3km HDF file
s1.yyddd.hhmm.mod06ct.hdf	- Cloud top properties/phase only HDF file
s1.yyddd.hhmm.mod06.hdf	- Cloud top properties/phase and optical properties HDF file
s1.yyddd.hhmm.mod07.hdf	- Atmospheric Profiles HDF file
s1.yyddd.hhmm.mod28.hdf	- Sea surface temperatures HDF file
s1.yyddd.hhmm.mod28.hdr	- Sea surface temperatures header file
s1.yyddd.hhmm.mod28.img	- Sea surface temperatures binary file
s1.yyddd.hhmm.mod28debug.txt	- Sea surface temperatures debug text file
s1.yyddd.hhmm.mod28.cfg	- Sea surface temperatures configuration file list of inputs/output file names
s1.yyddd.hhmm.wvnir.hdf	- Near infrared water vapor HDF file
s1.yyddd.hhmm.wvnir.hdr	- Near infrared water vapor header file
s1.yyddd.hhmm.wvnir.img	- Near infrared water vapor binary file
s1.yyddd.hhmm.wvnir.cfg	- Near infrared water vapor configuration file list of inputs/output file names

Polar region only files: (North of 60 N Latitude and South of 60 S Latitude)

- s1.yyddd.hhmm.snowmask.hdf - Polar snow mask HDF file
- s1.yyddd.hhmm.snowmask.bin - Polar snow mask binary file

- s1.yyddd.hhmm.ist.hdf - Polar ice surface temperature HDF file
- s1.yyddd.hhmm.ist.bin - Polar ice surface temperature binary file

- s1.yyddd.hhmm.inversion.hdf - Polar inversion strength and depth HDF file
- s1.yyddd.hhmm.inversion_strength.bin - Polar inversion strength binary file
- s1.yyddd.hhmm.inversion_depth.bin - Polar inversion depth binary file

- s1.yyddd.hhmm.icecon.hdf - Polar ice cover and concentration HDF file
- s1.yyddd.hhmm.icecon.bin - Polar ice cover and concentration binary file

Intermediate files will remain in the temporary directory that is created during processing. For the input Aqua test data set, these files are:

- a1.14063.1450.1000m.hdr
MODIS extracted Level 1B 1km header file
- a1.14063.1450.1000m.img
MODIS extracted Level 1B 1km binary image file
- a1.14063.1450.250m.hdr
MODIS extracted Level 1B 250m header file
- a1.14063.1450.250m.img
MODIS extracted Level 1B 250m binary image file
- a1.14063.1450.500m.hdr
MODIS extracted Level 1B 500m header file
- a1.14063.1450.500m.img
MODIS extracted Level 1B 500m binary image file
- a1.14063.1450.geo.hdr
MODIS extracted geolocation header file
- a1.14063.1450.geo.img
MODIS extracted geolocation binary image file
- a1.14063.1450.met.hdr
MODIS extracted Level 1B met header file
- a1.14063.1450.met.img
MODIS extracted Level 1B met binary image file (scan type and mirror side information)

In addition, the run script will automatically download the original ancillary data files from the IMAPP ancillary data ftp site to the location you set for LOCAL_ANC_DIR in the /env script. This defaults to \$MODIS_L2_HOME/ancillary.

The downloaded dynamic ancillary files for our test data are:

eng.140304	Ice concentration global grib file
gdas1.PGrbF00.140304.00z, gdas1.PGrbF00.140304.06z, gdas1.PGrbF00.140304.12z, gdas1.PGrbF00.140304.18z	Global model analysis grib files
NISE_SSMIF13_20140304.HDFEOS	Snow/ice cover HDFEOS file
TOAST16_140304.GRB	Total ozone global grib file
oisst.20140305	Reynolds blended SST global binary file
MYDCSR_B.A2014055.006.2014122061012.hdf	MODIS Aqua 8 Day Clear Sky Radiance File

These files will not be deleted automatically in case you wish to archive the files. If you want the directories and files to be deleted, you must delete them yourselves.

NOTE: The format of the IMAPP output atmospheric product HDF files are now IDENTICAL to the official NASA archive products. The differences in the products may be due to the fact that some ancillary files (ex: model analysis versus forecast) are not available in real time. For a description of the output products, please see the product descriptions located in the \$MODIS_L2_HOME/doc directory.

(4.8) Create Quicklook Images

A distribution of Python for creating quicklook images of the products is included with the MODIS Level 2 software package. The quicklook plotting script will be automatically run unless the `--noquicklook` flag is chosen. The quicklook images will be created in the output image file directory set in the \$MODIS_L2_HOME/env/imapp_modisl2.bash_env script (MODIS_L2_IMAGES, which defaults to \$MODIS_L2_HOME/images).

The images are created in the .PNG format from the HDF output files. No images are created from the binary files. The default image size is 1280 x 960 pixels. Users can select from four (4) output image size by setting the environmental variable MODIS_L2_RES to a value of 1,2,3 or 4 in the \$MODIS_L2_HOME/env/imapp_modisl2.bash_env script, where:

- 1 = output image size of 640 x 480,
- 2 = output image size of 800 x 600,
- 3 = output image size of 1280 x 960 (default), and
- 4 = output image size of 1600 x 1200.

The number of images created will depend upon the products you choose to create and whether the input data set is a day or night product. The full set of images produced when running the sample data set (daytime pass) are as follows:

- Aqua_20140304_1450_AerosolOpticalDepth10km.png
- Aqua_20140304_1450_AerosolOpticalDepth3km.png
- Aqua_20140304_1450_Band1.png
- Aqua_20140304_1450_Band7.png
- Aqua_20140304_1450_Band26.png
- Aqua_20140304_1450_Band27.png
- Aqua_20140304_1450_Band31.png
- Aqua_20140304_1450_TotalPrecipitableWater.png
- Aqua_20140304_1450_SeaSurfaceTemperature.png
- Aqua_20140304_1450_CloudMask.png
- Aqua_20140304_1450_CloudPhase.png
- Aqua_20140304_1450_CloudTopPressure.png
- Aqua_20140304_1450_CloudEffectiveRadius.png
- Aqua_20140304_1450_CloudOpticalThickness.png

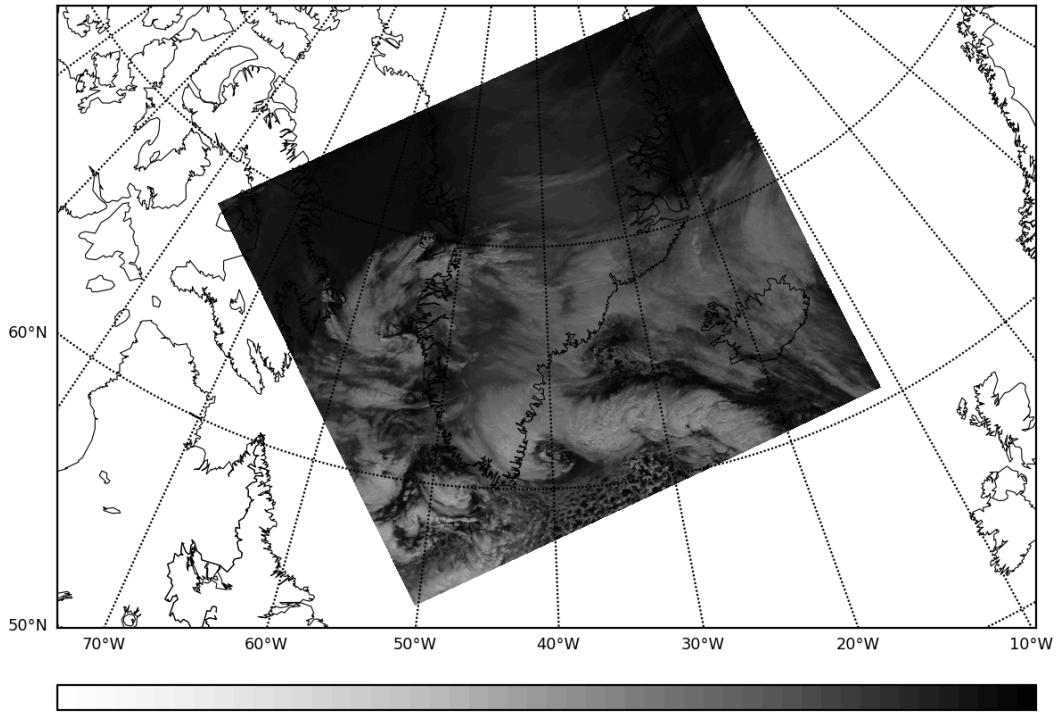
If the polar products are created, the following images are also created:

- Aqua_20140304_1450_IceConcentration.png
- Aqua_20140304_1450_IceMask.png
- Aqua_20140304_1450_IceTemp.png
- Aqua_20140304_1450_InversionDepth.png
- Aqua_20140304_1450_InversionStrength.png
- Aqua_20140304_1450_SnowMask.png

This sample set of images is included in the IMAPP_MODISL2_V3.1_INPUT_OUTPUT tar file. When you unpack this file, it will contain an IMAPP_MODISL2_V3.1_INPUT_OUTPUT/images directory. Four of the images (Band 26 reflectances, Cloud Mask, Cloud Top Pressure and Ice Mask) are displayed below.

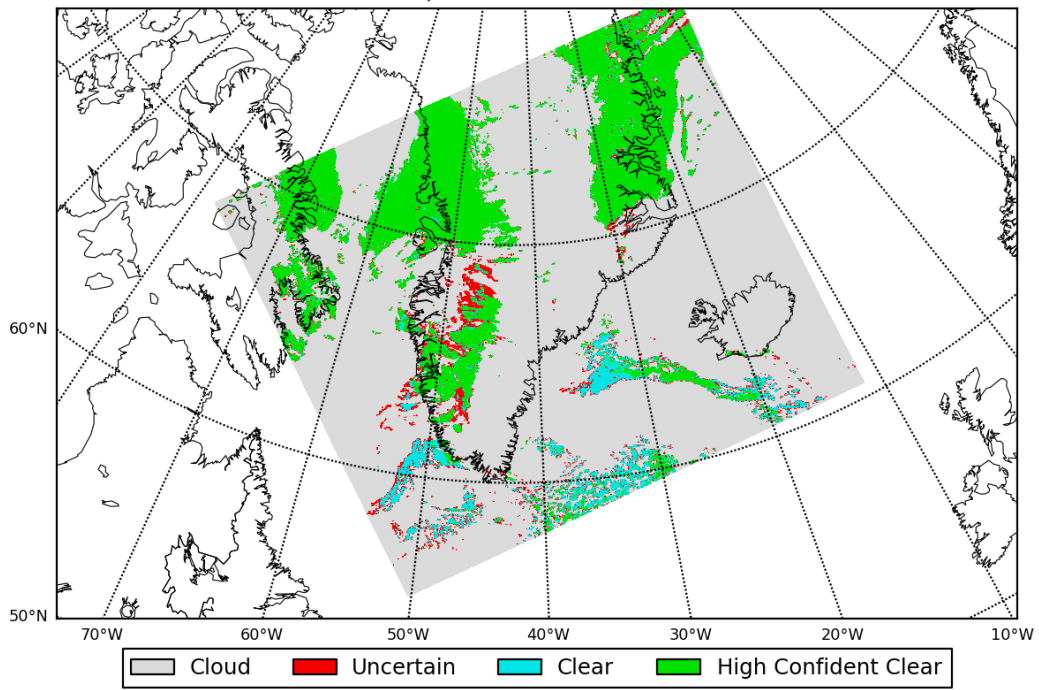
MODIS Band 26

Aqua 20140304 1450 UTC



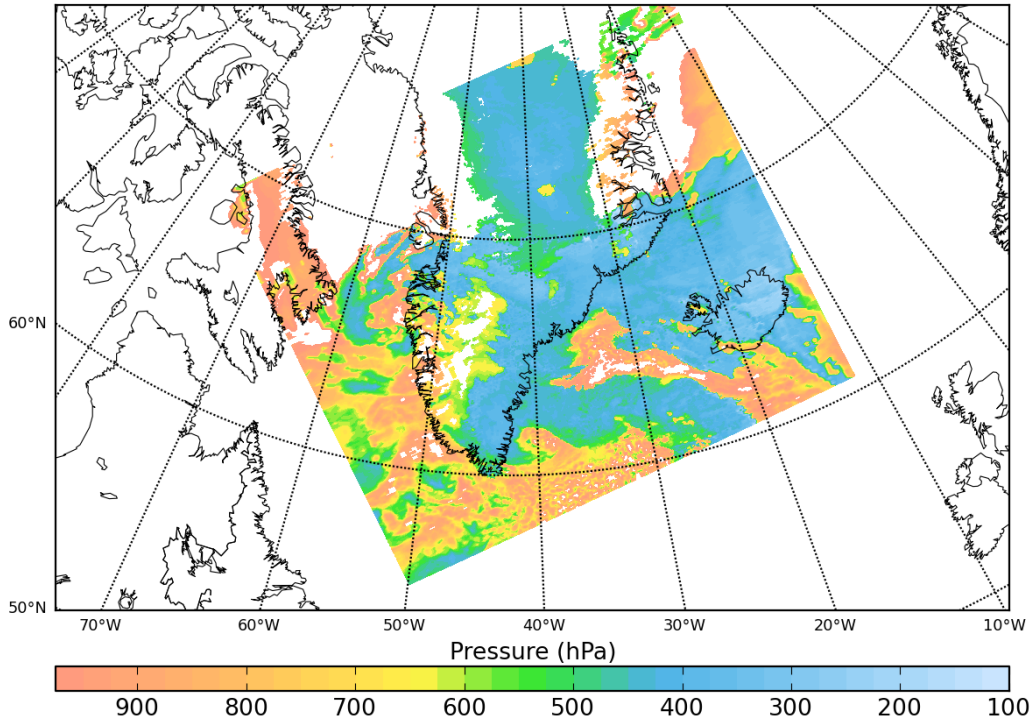
MODIS Cloud Mask

Aqua 20140304 1450 UTC



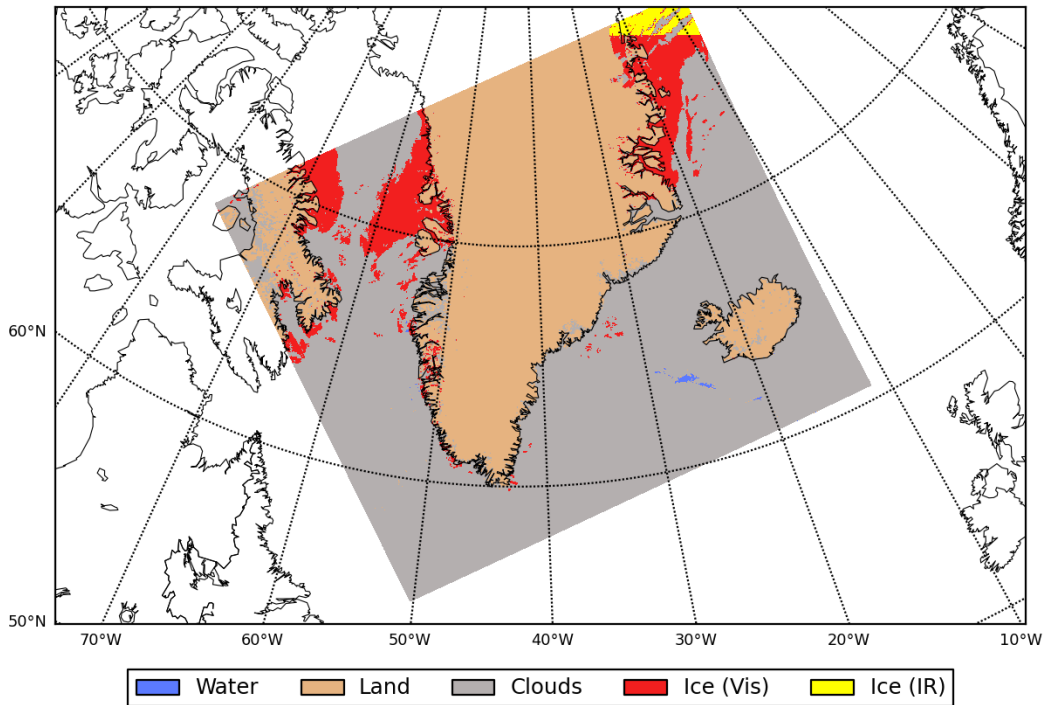
MODIS Cloud Top Pressure

Aqua 20140304 1450 UTC



MODIS Ice Mask

Aqua 20140304 1450 UTC



5.0 VERIFYING THE OUTPUT PACKAGE

One test MODIS Aqua data set is located in the IMAPP_MODISL2_V3.1_INPUT_OUTPUT.tar.gz file. Download the file from the IMAPP ftp site:

<ftp://ftp.ssec.wisc.edu/pub/IMAPP/beta/modisl2/>

and unpack the data sets. For test purposes, you may want to copy the input files into the \$MODIS_L2_HOME/input_data directory, e.g.,

```
cd $MODIS_L2_HOME/..
tar zxvf IMAPP_MODISL2_V3.1_INPUT_OUTPUT.tar.gz
cd IMAPP_MODISL2_V3.1_INPUT_OUTPUT
cp test_input/*.hdf $MODIS_L2_HOME/input_data
```

This will unpack all the input files needed to create the MODIS level2 IMAPP products:

a1.14063.1450.1000m.hdf	- Aqua MODIS 1km L1B input file
a1.14063.1450.250m.hdf	- Aqua MODIS 250m L1B input file
a1.14063.1450.500m.hdf	- Aqua MODIS 500m L1B input file
a1.14063.1450.geo.hdf	- Aqua MODIS 1km geolocation file

NOTE: You must make sure that all of the input files are located within the same directory.

Create all of the MODIS IMAPP Level 2 products for this example by typing:

```
modis_level2.sh \  
$MODIS_L2_HOME/input_data/a1.14063.1450.1000m.hdf \  
$MODIS_L2_HOME/products
```

NOTE: You can execute the software from any directory as long as the \$MODIS_L2_HOME environmental variable has been set correctly and you include the path to the input L1B 1km file.

A directory will be created with the starting date/time of the run included in the name. This directory is where execution takes place, and all intermediate files

will be placed here. The final output products will be copied into the output directory read in as the third argument to modis_level2.sh.

Output files will be created for the chosen products. A complete set of output product files is available in the IMAPP_MODISL2_V3.1_INPUT_OUTPUT.tar.gz file for the test input granule. You can compare the output hdf file products by executing the following commands:

```
cd IMAPP_MODISL2_V3.1_INPUT_OUTPUT/test_output
modisl2_compare.bash . $MODIS_L2_HOME/products/
```

This script will compare each output hdf file found in the test_output products directory with each matched named file found in the \$MODIS_L2_HOME/products/ directory. Values found for any arrays in the files that are outside a tolerance will be listed. There should be few if any differences. If you see many differences, please let us know.

Direct binary file comparison can be attempted by using the unix cmp command on the binary.bin files located in the /test_output directory, and the unix diff command on the text output files. Also from the /test_output directory, you may type (by way of example):

```
cmp a1.14063.1450.icecon.bin \
$MODIS_L2_HOME/products/a1.14063.1450.icecon.bin
```

```
diff a1.14063.1450.mod28debug.txt \
$MODIS_L2_HOME/products/a1.14063.1450.mod28debug.txt
```

Again, these files were created on a little endian machine. Binary files created on a big endian machine must be byte flipped prior to any comparison.

Appendix 1: Cloud Mask First Byte Product

A new HDF4 product file is created as part of MODIS Aqua and Terra IMAPP Level 2 software execution that consists of parameters in the first byte of the MOD35 output file product written into separate integer arrays. Included in these arrays are information contained in the Cloud Mask Quality_Assurance for the first byte, so that no other file or array needs to be accessed. This makes it easier to extract the cloud mask and other processing path information. A dump of the file header contents of the output validation product file follows:

```
a1.14063.1450.mask_byte1 {dimensions:
```

```
Cell_Along_Swath_1km = 2030 ;
```

```
Cell_Across_Swath_1km = 1354 ;
```

```
Cell_Along_Swath_5km = 406 ;
```

```
Cell_Across_Swath_5km = 270 ;
```

variables:

```
short MODIS_Cloud_Mask(Cell_Along_Swath_1km,Cell_Across_Swath_1km) ;
```

```
MODIS_Cloud_Mask:long_name = "MODIS Cloud Mask Categories:
```

```
9999 - No Mask Determined, 1 - Cloudy, 2 - Undetermined 3 - Confident Clear, 4 - High  
Confident Clear" ;
```

```
MODIS_Cloud_Mask:_FillValue = 9999s ;
```

```
MODIS_Cloud_Mask:valid_range = 0s, 4s ;
```

```
MODIS_Cloud_Mask:scale_factor = 1. ;
```

```
MODIS_Cloud_Mask:add_offset = 0. ;
```

```
short MODIS_Day_Night_Flag(Cell_Along_Swath_1km, Cell_Across_Swath_1km) ;
```

```
MODIS_Day_Night_Flag:long_name = "MODIS Day or Night Flag:
```

```
9999 - No Mask Determined, 1 - Night, 2 - Day" ;
```

```
MODIS_Day_Night_Flag:_FillValue = 9999s ;
```

```
MODIS_Day_Night_Flag:valid_range = 0s, 2s ;
```

```
MODIS_Day_Night_Flag:scale_factor = 1. ;
```

```
MODIS_Day_Night_Flag:add_offset = 0. ;
```

```
short MODIS_Sunlint_Flag(Cell_Along_Swath_1km, Cell_Across_Swath_1km) ;
```

```
MODIS_Sunlint_Flag:long_name = "MODIS Sunlint Flag:
```

```
9999 - No Mask Determined, 1 - Sunlint in Pixel, 2 - No Sunlint in Pixel" ;
```

```
MODIS_Sunlint_Flag:_FillValue = 9999s ;
```

```
MODIS_Sunlint_Flag:valid_range = 0s, 2s ;
```

```
MODIS_Sunlint_Flag:scale_factor = 1. ;
```

```
MODIS_Sunlint_Flag:add_offset = 0. ;
```

```
short MODIS_Snow_Ice_Flag(Cell_Along_Swath_1km, Cell_Across_Swath_1km) ;
```

```
MODIS_Snow_Ice_Flag:long_name = "MODIS Snow/Ice Flag:
```

```
9999 - No Mask Determined, 1 - Snow/Ice in Pixel, 2 - No Snow/Ice in Pixel" ;
```

```
MODIS_Snow_Ice_Flag:_FillValue = 9999s ;
```

```
MODIS_Snow_Ice_Flag:valid_range = 0s, 2s ;
```

```
MODIS_Snow_Ice_Flag:scale_factor = 1. ;
```

```
MODIS_Snow_Ice_Flag:add_offset = 0. ;
```

```
short MODIS_Simple_LandSea_Mask(Cell_Along_Swath_1km, Cell_Across_Swath_1km) ;
```

```

    MODIS_Simple_LandSea_Mask:long_name = "MODIS Simple Land and Sea Mask
Categories: 9999 - No Mask Determined, 1 - Water, 2 - Coast 3 - Desert, 4 - Land" ;
    MODIS_Simple_LandSea_Mask:_FillValue = 9999s ;
    MODIS_Simple_LandSea_Mask:valid_range = 0s, 4s ;
    MODIS_Simple_LandSea_Mask:scale_factor = 1. ;
    MODIS_Simple_LandSea_Mask:add_offset = 0. ;
float Latitude(Cell_Along_Swath_5km, Cell_Across_Swath_5km) ;
    Latitude:long_name = "Geodetic Latitude" ;
    Latitude:_FillValue = -999.98999f ;
    Latitude:valid_range = -90.f, 90.f ;
    Latitude:scale_factor = 1. ;
    Latitude:add_offset = 0. ;
float Longitude(Cell_Along_Swath_5km, Cell_Across_Swath_5km) ;
    Longitude:long_name = "Geodetic Longitude" ;
    Longitude:_FillValue = -999.98999f ;
    Longitude:valid_range = -180.f, 180.f ;
    Longitude:scale_factor = 1. ;
    Longitude:add_offset = 0. ;
}

```

Appendix 2: IMAPP Product Validation

To verify that the IMAPP MODIS Level 2 V3.1 software products are comparable to the operational NASA atmosphere products, an entire day of Collection 6 Aqua MODIS Level 1B data from 24 July 2014 was downloaded from the Level 1 and Atmosphere Archive and Distribution System (LAADS) and processed. The official NASA Collection 6 MOD35 cloud mask, MOD06CT cloud top properties, MOD07 atmospheric profiles, and MOD04 aerosol products for the same day were also downloaded from LAADS for comparison with the IMAPP output. The comparison of the IMAPP MODIS Level 2 products with the official products was done using the HDF “hdiff” tool.

The IMAPP Level 2 and official LAADS MOD35 cloud mask products are similar, and often identical, when the National Snow & Ice Data Center snow/ice HDFEOS file from the day after the date of the Level 1B file is used as input. In the comparisons for 4 March 2014, the swaths with the most differences were all nighttime swaths. When the MOD35 first byte output are compared, only 16 of the 288 files have differences in over 1% of the points in the swath and only 4 of those have differences in over 10% of the points. The number of differences for the daytime swaths are generally zero or very close to it. However, the NISE file for the day after will not be available for real time processing. The snow/ice file for the same date as the Level 1B file being processed will be used for real time processing when it is available. When that is done, the percentage of points that differ between the IMAPP MODIS Level 2 and LAADS MOD35 cloud mask products are still generally close to zero.

The MOD06CT products, including cloud fraction, cloud phase, cloud top pressure, and cloud top temperature, have differences close to zero. If a MOD35 file that differs from the official LAADS MOD35 file is used as an input to the MOD06CT algorithm, the discrepancies in the MOD06CT products will likely be larger since differences that are introduced in the MOD35 processing propagate to the subsequent products that use the MOD35 output file as input.

The IMAPP MODIS Level 2 and LAADS MOD07 products from daytime swaths produced identical results.

MOD04 product creation uses both the MOD35 cloud mask and MOD07 atmospheric profiles product files as inputs, so any differences in those products would propagate to the MOD04 products. Only a few swaths of the 10km MOD04 products have more than 1% of the points that differ from the official

products for the combined Dark Target and Deep Blue product. The differences in the 3km MOD04 products are much less than for the 10km MOD04 products and show up in much less than one percent of the points in any of the swaths compared.

Table 1: Statistics showing the comparison between IMAPP Aqua output products and NASA LAADS archive products for a set of key parameters. The statistics were made for a day of Aqua MODIS data from 24 July 2014.

Array Name	Number of granules processed	Number of granules where > 1% of points differ	Number of granules where > 10% of points differ
Mask Byte 1	289	16	4
Cloud Top Pressure (using LAADS MOD35)	289	5	0
Total Precipitable Water (using LAADS MOD35)	289	0	0
10km AOD Dark Target and Deep Blue Combined (using LAADS MOD35)	142	21	3
3km AOD Land and Ocean (using LAADS MOD35)	142	0	0