

Obtaining and Processing MODIS Data

MODIS is an extensive program using sensors on two satellites that each provide complete daily coverage of the earth. The data have a variety of resolutions; spectral, spatial and temporal. The MODIS web site, <http://modis.gsfc.nasa.gov/index.php>, is a good place to begin learning about this important program. This site has links to the Atmospheres, Land and Oceans groups of MODIS. Because the MODIS sensor is carried on both the Terra and Aqua satellites, it is generally possible to obtain images in the morning (Terra) and the afternoon (Aqua) for any particular location. Night time data are also available in the thermal range of the spectrum. You should consider time of day when ordering a scene for a specific day.

While you can order a daily scene for any specific date and location, many consolidated products have been developed with MODIS data. These include 8-day or 16-day composite images, a variety of indices, and a range of other global products with different time scales. To learn more about the various MODIS products, view the MODIS land data products page at: <http://edcdaac.usgs.gov/modis/dataproduct.html>.

MODIS data may be available at different collection, or version, processing levels. Data for version 4 and above have been validated and approved for scientific research. As of this writing, reprocessing of version 4 data to version 5 levels has begun, and all new acquisitions are at the version 5 level.

1. Identify Data of Interest

Before placing an order for data you need to identify the type of data you wish to use. MODIS data can be placed in two broad categories; daily scenes and derived products. Products are further separated into Land, Atmosphere, and Ocean groups. You can view the list of MODIS *Land* products at: <http://edcdaac.usgs.gov/modis/dataproducts.asp>. *Cryosphere* data and descriptions can be found at the National Snow and Ice Data Center at: <http://nsidc.org/daac/modis/index.html>. *Atmosphere* product descriptions can be found at: <http://modis-atmos.gsfc.nasa.gov/products.html>. Information about MODIS *Ocean* data can be found at: <http://modis.gsfc.nasa.gov/oceanChoice.php>.

Next you need to decide where and when you want data coverage. Locations for full daily scenes and products can be entered using latitude and longitude. If you do not know this information, one method of obtaining this would be to select a city in the region of interest and read the coordinates from the back of an atlas. You could also use Google Earth to locate your area of interest and read the coordinates displayed on the screen. Processed MODIS data such as the Surface Reflectance products are normally segmented into tiles with an area of 10° X 10°.

Dates are in the Julian format, i.e. yyyyddd. There is a Julian Date Converter program in the CEO Lab Tools folder on the CEO workstations. Also several freeware date converter programs are available on the Internet. Time is in Universal Time Coordinated (UTC). The data are provided in the HDF-EOS format.

Daily MODIS Scenes – Level 1

Individual daily MODIS scenes, MODIS *Level 1* products, can be obtained for any part of the earth, every day, since February 2000. These files are in the Geographic projection and have a spatial resolution of 1 km. There are 36 bands of image data interspersed through 85 total bands of information in the file. The data are digital numbers in *16 bit unsigned integer* format. These data should be converted to radiance values, surface reflectance values, and/or brightness/temperature values before performing any analysis.

Terra file names for the complete file begin with MOD021KM. Aqua file names begin with MYD021KM. The product name on the MODIS ordering site is:

“Calibrated Radiances 5-Min L1B Swath 1KM”.

Alternatively you can obtain daily scenes at 500 m resolution which would include the first 7 bands of data, or the first two bands of data at 250 m resolution. The Terra names for these are MOD02HKM and MOD02QKM respectively.

MODIS Products - Level 2

As mentioned earlier, many products have been developed from MODIS data. You should read the product descriptions for each product you intend to use. This will provide information about data range, scaling values, fill values, data type and format, etc. Product data are generally provided in the sinusoidal projection. Below are descriptions of the surface reflectance and vegetation products, but many more products are available.

Surface Reflectance Products

The surface reflectance products are generated from the first two, or seven, bands of the corresponding full 36 band scenes. These provide an estimated “at surface” spectral reflectance. Several algorithms are applied to various MODIS bands to remove the effects of cirrus clouds, water vapor, aerosols and atmospheric gases. Global surface reflectance products can be obtained at either 250 m or 500 m spatial resolution, as daily or 8-day composite images.

The data type is *16 bit signed integer*, which has a theoretical range of values from -32,768 to +32,768. The documented data range is from -100 to +16000 with a fill value of -28,672. If you wish to convert these numbers to a valid reflectance data range, cell values should be divided by 10,000. These data must then be stored with a float data type of IEEE 4 byte real.

The data are provided in the HDF-EOS format. Version 4 and above MODIS data use the Sinusoidal projection with the WGS84 datum.

MOD09GQK - MODIS Surface Reflectance Daily L2G Global 250m

This file has a spatial resolution of 250 m and contains two bands of spectral data centered at 645 nm and 858 nm. There are also three bands of additional information on band quality, orbit and coverage, and number of observations.

MOD09Q1 - MODIS Surface Reflectance 8-Day L3 Global 250m

This file is a composite using eight consecutive daily 250 m images. The “best” observation during each eight day period, for every cell in the image, is retained. This helps reduce or eliminate clouds from a scene. The file contains the same spectral information as the daily file listed above, centered at 645 nm and 858 nm. There is one additional band of data for quality control.

MOD09GHK - MODIS Surface Reflectance Daily L2G Global 500m

This file has a spatial resolution of 500 m and contains seven bands of spectral data plus three bands of additional information on band quality, orbit and coverage, and number of observations. The spectral range for each band can be found in Appendix A, bands 1 through 7.

MOD09A1 - MODIS Surface Reflectance 8-Day L3 Global 500m

This file is a composite using eight consecutive daily 500 m images. The “best” observation during each eight day period, for every cell in the image, is retained. This helps reduce or eliminate clouds from a scene. The file contains the same seven spectral bands of data as the daily file listed above. It also has an additional 6 bands of information concerning quality control, solar zenith, view zenith, relative azimuth, surface reflectance 500 m state flags, and surface reflectance day of year.

Vegetation Index Products

There are several composite MODIS vegetation products. Sixteen-day composites are available at 250 m, 500 m, 1 km, and 0.05 degree resolutions. There are also monthly composites with 1 km, and 0.05 degree resolutions. Each file contains bands of data for both the traditional Normalized Difference Vegetation Index (NDVI) and new Enhanced Vegetation Index (EVI). There are also bands of data for quality control in each file.

The data type is *16 bit signed integer*, which has a theoretical range of values from -32,768 to +32,768. The documented data range is from -2000 to +10000 with a fill value of -3000. If you wish to convert these numbers to the traditional data range, cell values should be divided by 10,000. These data must then be stored with a float data type of IEEE 4 byte real.

The Vegetation Index products have a label prefix of MOD13 for the Terra sensor and MYD13 for the Aqua sensor. On the ordering web page the product name indicates the sensor, composite period, spatial resolution, and data version number. For example, “*MODIS/TERRA Vegetation Indices 16-day L3 Global 250m Sin Grid V004*” will get you the data from Terra for a 16-day composite at 250 m resolution in the sinusoidal projection using the version 4 data.

2. Ordering Data

MODIS data are freely available over the Internet. Before ordering data, you should review the product descriptions and metadata. This will help you identify the most appropriate data, and more accurately import these data. Data import instructions are contained in Section 3 Importing and Image Processing.

Note: While it is tempting to immediately obtain a large amount of data, you should start with just one or two data sets. Only after you have had some experience importing *and actually working with* these initial data should you consider ordering additional data sets.

Daily Scenes – Level 1

Individual daily MODIS scenes can be obtained at the Level 1 and Atmosphere Archive and Distribution System (LAADS) at: <http://ladsweb.nascom.nasa.gov/data/search.html>. First specify the appropriate satellite(s); Terra, Aqua, or both. Under Group select **Level 1 Products** for the daily scenes. Then select the **Level 1B Calibrated Radiances** dataset at the spatial resolution you wish.

Next specify Temporal, Collection, and Spatial Selections. The temporal selection should be the starting and ending date of your research period. The collection will be either (version) 4 or 5. For Spatial selection you can select a MODIS tile or, perhaps more usefully, latitude and longitude. You can enter bounding box coordinates or drag a box over the map. Normally you will only enter the **Day Coverage Selection**. Once this information has been entered, click on the Search button on the bottom of the page.

View the browse images of the datasets that meet your search criteria. Once you select the datasets you need, add them to your *shopping cart*. When you are ready to place your order, go to the shopping cart to review the selected datasets. You should accept the default to order data without post processing and click on the Order button. Enter your email address and make sure the FTP Pull option is selected. Click the Order button again. You will receive an email when the data are available for download.

The order notification email will contain the ftp location and an order number. You can use an FTP program, or point your browser to the following link. Then proceed to the sub-directory of your order number.

<ftp://ladsweb.nascom.nasa.gov/orders>

Products – Level 2

MODIS Level 2 products are distributed through a variety of sites. This document will cover the Atmosphere and Land products. You can locate other types of MODIS data at the appropriate NASA Distributed Active Archive Center (DAAC). You can find these from the Links page of the CEO web site.

Atmosphere Products

MODIS Atmosphere products are located at the same LAADS site that MODIS Daily scenes are distributed at: <http://ladsweb.nascom.nasa.gov/data/search.html>. You should follow the same navigation and search procedures as described above, only under Group select *Atmosphere Level 2* or *Level 3 Products*.

Land Products

MODIS Land as well as selected Cryosphere and Ocean products can be found at the following site: <http://edcimswww.cr.usgs.gov/pub/imswelcome/>

In the Choose Data Sets section, under one of the disciplines, click on the MODIS/Aqua or MODIS/Terra button and then select the specific product by name. You also need to select a specific area and date range for your data search.

You can enter a location as either a bounding box or point in latitude/longitude. Values can be entered as decimal degrees or degrees:minutes:seconds (separated by colons). Next select a date range and click on the “Submit Search” button. After a short while you should see a list of scenes that meet your selection criteria. There will be browse images for most of the data granules to help you select appropriate scenes. You can select multiple scenes and add them to your “shopping cart”.

When you have completed your selections you will need to fill in your name, address and affiliation. There are no costs for these data. Select the “**ftp pull**” delivery option. You will receive an initial notification acknowledging your order within an hour. By the next day you should be notified where to connect to “ftp” the data from the EDC to your workstation.

Once you download the files in HDF format you can open them in ERMapper. As of this writing ERMapper cannot read the coordinate information from the HDF file. We recommend using the program ENVI to process the data and save them into ERMapper format. Instructions on how to prepare these data for use in ERMapper follows in Section 3.

3. Image Processing and Import to ERMMapper Format

As stated above, ERMMapper can directly open MODIS HDF files but cannot read coordinate information from these files. You should process these data using ENVI, and save the results to an ERMMapper format file if you wish to work with the data in that program. MODIS products are distributed using the sinusoidal projection in 10° tiles. Daily scenes have geographic coordinate information embedded in the file. Instructions for processing each type of data are described below.

This processing will be much faster when using the local C:\ drive. You can create a new directory called C:\Temp\”*your_name*” and place the HDF file(s) here. After you have completed processing the MODIS data, copy the final ERMMapper dataset to your own directory space on the U:\ drive. Remember that each ERMMapper dataset consists of two files; “*basename*” and “*basename.ers*”. It is important that you remove *all* files from this temporary work space on the C:\ drive before you log off of the workstation.

Note: When system maintenance is performed on lab workstations user data stored on the C:\ drive is removed. This includes data located in C:\Temp or stored on user “Desktops”. Only data stored on the server are retained and backed up.

MODIS Daily Scene

MODIS daily scenes have the following prefix as part of their file name; MOD021KM (Terra) or MYD021KM (Aqua). ENVI calculates *surface reflectance*, *radiance*, and *brightness/temperature* automatically when it opens a full “one kilometer” daily scene. You will see three separate listings in the “Available Bands List” window; identified as Reflectance, Radiance, and Emissive respectively (Figure 1). Each “file” must be processed separately.

Initially these files do not have coordinate information, but ENVI can generate this automatically. From the main menu select **Map | Georeference MODIS**. Select a file, click on the “Spectral Subset” button if you wish to use only a few bands of data, and click OK. In the “Georeference MODIS Parameters” window select the desired output map projection and datum and click OK again. ENVI defaults to selecting the UTM projection. These datasets cover an area much larger than a single UTM zone so you should select the **Geographic** projection and click OK. Finally in the “Registration Parameters” window direct your output to **memory**, ignoring any error messages about exceeding available memory space.

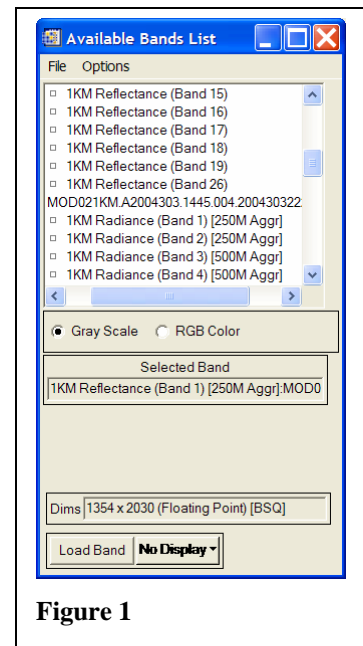


Figure 1

When the georeferencing is complete ENVI places a new file with the prefix “Warp” in the Available Bands List. Double click the globe icon to display the coordinate information for this scene. You can view this in a display and confirm the coordinate

information using the “Cursor Location/Value” tool. Once you are satisfied with your work save this file in ERMapper format. From the ENVI main menu select: **File | Save File As | ER Mapper**, making sure you navigate to your work space on the **C:\Temp** subdirectory and enter a unique filename. Once the save is complete use ERMapper to browse the scene and examine the coordinate information.

When ENVI saves a file using the UTM projection, coordinate information is placed in the ERMapper header file. If you followed the above recommendations, ENVI has produced the new ERMapper file with data in the **Geographic** projection and the coordinate information may *not* be placed in the ERMapper header file. You will need to edit the header file to add datum, projection, pixel size and coordinates of the upper left (0, 0) pixel. This information can be found under the globe icon of the warped ENVI file. You should also define the appropriate null value for the data, typically zero. See the separate document “Editing ERMapper Header Information” in the FAQ section of the CEO web site for detailed instructions on how to edit the file.

Once this is completed you can add band names and spectral range information. See the CEO staff for a shortcut to do this. Finally copy the ERMapper dataset (both files) to your U:\ drive, close ENVI, and remove *all* of the datasets *and* your subdirectory.

MODIS Products – i.e. Surface Reflectance or Vegetation Indices

As noted above, the MODIS data are in HDF format using a sinusoidal projection. ERMapper can read these data, but not the coordinate information. It is recommended that the data be processed in ENVI and saved in ERMapper format.

Open the MODIS product HDF file in ENVI. Depending on the product, ENVI will open the data as one or more datasets. For example, the MOD09GHK 500 m daily surface reflectance file will open as a single 7-band file. The MOD13Q 16 day 250 m vegetation index file opens as three separate datasets, a 4-band surface reflectance dataset and two single band indices (Figure 2). Each “file” must be processed separately. For each file you can click on the globe icon to display coordinate information.

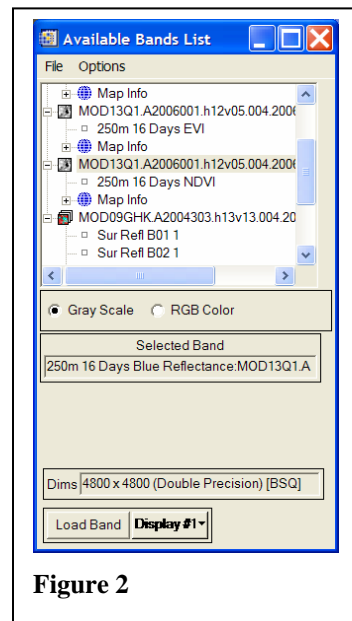


Figure 2

The next step will be to change the file(s) from sinusoidal to an alternate projection. Since each MODIS product tile spans more than 1,000 km, you should not select UTM as a new projection. From the ENVI main menu select **Map | Convert Map Projection**. Select a file and spectrally subset this to fewer bands if desired. Click OK to open the “Convert Map Projection Parameters” window. Click the “Change Proj...” button and select a datum and projection. WGS 84 datum and Geographic Lat/Lon projection are recommended. Set the Background Value to the documented fill value for the product (this value is -3000 for vegetation indices and -28672 for surface reflectance). Accept all other defaults and, using the “Output Results” radio button, select “Memory”. This will create a new file in memory with a prefix of “Warp”. Use the globe icon to confirm the new coordinates.

Now save this new file to ERMapper format. From the main ENVI menu select: **File | Save File As | ER Mapper**. Select the warped file in memory and in the “Output File to ER Mapper” window navigate to the temporary directory on the C:\ drive. Enter a unique filename and click OK. ENVI will append “.ers” to your filename and create the ERMapper file.

While ENVI has produced a new ERMapper file with data in the geographic projection, the coordinate information has *not* been placed in the ERMapper header file. You will need to edit the header file to add datum, projection, pixel size and coordinates of the upper left (0, 0) pixel. This information can be found under the globe icon of the warped ENVI file. You should also define the appropriate null value for the data. The documentation on the Surface Reflectance products states the null value is -28672 and for the Vegetation Indices products the null value is -3000. See the separate document “Editing ERMapper Header Information” in the FAQ section of the CEO web site for detailed instructions on how to edit this file.

When you have entered all information and saved the results, open the new file in ERMapper again. You should have good data with proper coordinate information. After verifying this, copy the ERMapper dataset (both the base file and the “.ers” header file) to your U:\ drive, close ENVI, and remove *all* of the datasets *and* your temporary subdirectory.

Appendix A – Description of the 36 Band in a Full MODIS Scene

BAND	RANGE nm reflected	RANGE um emitted	KEY USE
1	620-670		Absolute Land Cover Transformation, Vegetation Chlorophyll
2	841-876		Cloud Amount, Vegetation Land Cover Transformation
3	459-479		Soil/Vegetation Differences
4	545-565		Green Vegetation
5	1230-1250		Leaf/Canopy Differences
6	1628-1652		Snow/Cloud Differences
7	2105-2155		Cloud Properties, Land Properties
8	405-420		Chlorophyll
9	438-448		Chlorophyll
10	483-493		Chlorophyll
11	526-536		Chlorophyll
12	546-556		Sediments
13h	662-672		Atmosphere, Sediments
13l	662-672		Atmosphere, Sediments
14h	673-683		Chlorophyll Fluorescence
14l	673-683		Chlorophyll Fluorescence
15	743-753		Aerosol Properties
16	862-877		Aerosol Properties, Atmospheric Properties
17	890-920		Atmospheric Properties, Cloud Properties
18	931-941		Atmospheric Properties, Cloud Properties
19	915-965		Atmospheric Properties, Cloud Properties
20		3.660-3.840	Sea Surface Temperature
21		3.929-3.989	Forest Fires & Volcanoes
22		3.929-3.989	Cloud Temperature, Surface Temperature
23		4.020-4.080	Cloud Temperature, Surface Temperature
24		4.433-4.498	Cloud Fraction, Troposphere Temperature
25		4.482-4.549	Cloud Fraction, Troposphere Temperature
26	1.360-1.390		Cloud Fraction (Thin Cirrus), Troposphere Temp.
27		6.535-6.895	Mid Troposphere Humidity
28		7.175-7.475	Upper Troposphere Humidity
29		8.400-8.700	Surface Temperature
30		9.580-9.880	Total Ozone
31		10.780-11.280	Cloud Temperature, Forest Fires & Volcanoes, Surface Temp.
32		11.770-12.270	Cloud Height, Forest Fires & Volcanoes, Surface Temperature
33		13.185-13.485	Cloud Fraction, Cloud Height
34		13.485-13.785	Cloud Fraction, Cloud Height
35		13.785-14.085	Cloud Fraction, Cloud Height
36		14.085-14.385	Cloud Fraction, Cloud Height

This information was obtained from the Land Process Distributed Active Archive Center website on 13 June 2003 at the following URL:

<http://edcdaac.usgs.gov/modis/table2.html>

Appendix B – MODIS Bands After Processing into Reflectance and Brightness/Temperature Files

16 Brightness/Temperature Bands		22 Reflectance or Radiance Bands	
ERMapper	MODIS	ERMapper	MODIS
Band 1 =	Band 20 3.660-3.840	Band 1 =	Band 1 0.620-0.670
Band 2 =	Band 21 3.929-3.989	Band 2 =	Band 2 0.841-0.876
Band 3 =	Band 22 3.929-3.989	Band 3 =	Band 3 0.459-0.479
Band 4 =	Band 23 4.020-4.080	Band 4 =	Band 4 0.545-0.565
Band 5 =	Band 24 4.433-4.498	Band 5 =	Band 5 1.230-1.250
Band 6 =	Band 25 4.482-4.549	Band 6 =	Band 6 1.628-1.652
Band 7 =	Band 27 6.535-6.895	Band 7 =	Band 7 2.105-2.155
Band 8 =	Band 28 7.175-7.475	Band 8 =	Band 8 0.405-0.420
Band 9 =	Band 29 8.400-8.700	Band 9 =	Band 9 0.438-0.448
Band 10 =	Band 30 9.580-9.880	Band 10 =	Band 10 0.483-0.493
Band 11 =	Band 31 10.780-11.280	Band 11 =	Band 11 0.526-0.536
Band 12 =	Band 32 11.770-12.270	Band 12 =	Band 12 0.546-0.556
Band 13 =	Band 33 13.185-13.485	Band 13 =	Band 13L 0.662-0.672
Band 14 =	Band 34 13.485-13.785	Band 14 =	Band 13H 0.662-0.672
Band 15 =	Band 35 13.785-14.085	Band 15 =	Band 14L 0.673-0.683
Band 16 =	Band 36 14.085-14.385	Band 16 =	Band 14H 0.673-0.683
		Band 17 =	Band 15 0.743-0.753
		Band 18 =	Band 16 0.862-0.877
		Band 19 =	Band 17 0.890-0.920
		Band 20 =	Band 18 0.931-0.941
		Band 21 =	Band 19 0.915-0.965
		Band 22 =	Band 26 1.360-1.390