ATMO 611 – Satellite Data Applications Lab Assignment #2

50 Points Total Available

Global and Regional Cloud Properties – DUE Friday September 29th, 2017

This lab introduces simple techniques for visualizing spatial patterns in cloud properties including cloud top temperature, cloud top pressure, and cloud fraction. It will allow you to develop awareness of how different non-cloud features may be represented in these Cloud Property Values. Questions to be answered are labeled **Q1**, **Q2**, etc. and are highlighted in Red. Matlab coding on your own are highlighted in Green as **C1**, **C2**, etc.

1 AQUIRING MODIS L2 and L3 Data

Using the method of your choice you will order data from LAADS and download the .hdf files on to your account. We will be looking at L2 scenes and comparing them to L3 Daily and Monthly Gridded Averages. We will be using AQUA data for this Lab. Make sure you do not mistakenly download Terra data.

Make a folder to store your data so it's easy to access in Matlab. I called mine: **Lab 2 HDF Data

1) Download RGB and L2 Data for Specific Events

First Get the RGB images - Visit https://modis-images.gsfc.nasa.gov/IMAGES/02_1km_main.html

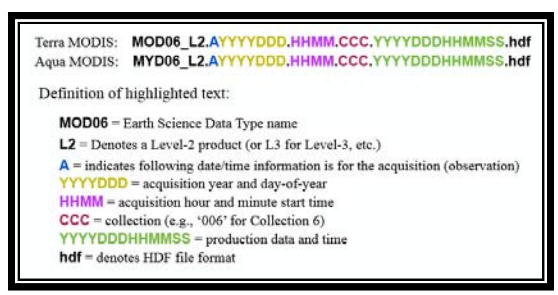
SAVE the following RGB images to include with your lab write up.

1) Date: April 15, 2010 Time: 1330 Day Number: 105
2) Date: August 1, 2013 Time: 1430 Day Number: 213
3) Date: November 2, 2013 Time: 0545 Day Number: 306

Q1 – (3 points) Based on the Visible RGB images from the website above, the dates, and geographic locations identify what event, or type of event, the images represent. You earn 1 point for each successful identification and RGB image. Include a short 1-2 sentence description of the event and a brief 1-2 sentence visual description of the image (e.g. What do you observe? Smoke, dust, sunglint, clouds). Make sure to cite any source material (weblinks or articles).

GET THE MATCHING L2 HDF FILES using LAADS Web: http://ladsweb.nascom.nasa.gov

Remember the filename data format is as follows →


Terra MODIS: MOD06_L2.AYYYYDDD.HHMM.CCC.YYYYDDDHHMMSS.hdf
Aqua MODIS: MYD06_L2.AYYYYDDD.HHMM.CCC.YYYYDDDHHMMSS.hdf

Definition of highlighted text:

MOD06 = Earth Science Data Type name
L2 = Denotes a Level-2 product (or L3 for Level-3, etc.)
A = indicates following date/time information is for the acquisition (observation)
YYYYDDD = acquisition year and day-of-year
HHMM = acquisition hour and minute start time
CCC = collection (e.g., '006' for Collection 6)
YYYYDDDHHMMSS = production data and time
hdf = denotes HDF file format

**Hint: Remember in LAADS to choose MODIS: Aqua, Collection 6, Cloud Properties, MYD06_L2.*

For TIME: You can click the +Advanced link and enter in the date with the specific time stamp YYYY-MM-DD HH:MM. You can even list ALL 5 dates and search for them at the same time!

For LOCATION: Choose "World" that way it'll search the globe for the specific files you wanted and you won't have to worry about knowing where the events are taking place.

DOWNLOAD them straight from the Files page if you don't want to wait for an email or have to do FTP.

2) Download Daily Averaged L3 Data
We'll be comparing L2 and L3 resolution data for the same day. Download the corresponding Daily Averaged L3 data from Aqua. You don't need to download any images for this step, just the raw .hdf files that you will import into Matlab.

**Hint: Remember in LAADS to choose MODIS: Aqua, Collection 6, L3 Atmosphere Product, MYDO8_D3*

Time to match the dates below (make sure you don't include the HH:MM and Location Global.

GET THESE L3 HDF FILES using LAADS web: **http://ladsweb.nascom.nasa.gov/data/search.html**
1) Date: April 15, 2010 Collection: 6
2) Date: August 1, 2013 Collection: 6
3) Date: November 2, 2013 Collection: 6

2 USING MATLAB TO MAP L2 CLOUD PROPERTIES

1) Start a new .m file in matlab, give it a name (L2_Cloud_Maps_Lab_2_Your_Last_Name.m for example).
You can save it anywhere, even inside the folder where you have saved your data.

If your .m file is not in your data folder you'll need to tell it to "change directories" to access the data files. You can do this by adding a line of code like this:

```
%
clear % Clears Matlab's memory, it's best to include it at the beginning of every code
%
cd ('Lab_2_HDF_Data'); % Change directories to where data is located
```

***Hint: If your .m file is NOT located in the same folder as your data you'll need to change directories BACK to where the code is found in order for it to run each time. You can do that by typing*

`cd ..` at the command line ">>" and hitting enter.

2) These files are different than the L3 data. We'll need to access the **geolocation data** included in the L2 files in order to make figures that look like the ones we can quick-preview on the MODIS LAADS site (which as before is a good check on what they should look like and the range for the units). We'll be using a different way to load the HDF data that allows us to access the geolocation data. See the example code below.

The variables you need to extract and get metadata including fill value, unit, scaling factor, offset are:
- Cloud_Top_Pressure
- Cloud_Fraction
- Cloud_Top_Temperature

I'll be using the 4-15-2010 data and Cloud_Top_Pressure as the example. You'll need to repeat the following code for Cloud_Fraction.

3) Reading in the File, extracting file description and assigning IDs – THIS IS DIFFERENT THAN LAB 1!

```
% reading in file
MODIS_ID_4_15_2010 = hdfsd ('start', MYD06_L2.A2010105.1330.006.2014071021245.hdf', 'read');
%
% extract info about file description
[numdata, numdescr] = hdfsd ('fileinfo', MODIS_ID_4_15_2010);
%
% assigning dataset ID(s)
CTPid = hdfsd ('select', MODIS_ID_4_15_2010, 23); % <-- you need to find the ID number through the
                                          % HDF viewer. it's not in the metadata, it's the "number"
                                          % data in the file. you can find this by "counting" up
                                          % from 2 for the arrays under "Data Fields." i.e. Scan-
                                          % Start_Time ID = 2, Solar_Zenith ID = 3, etc.
longid = hdfsd ('select', MODIS_ID_4_15_2010, 0); % Lonigtude has an ID of 0
latid = hdfsd ('select', MODIS_ID_4_15_2010, 1);  % Latitude has an ID of 1
%
```

4) Extracting information from the dataset using the 'getinfo' function to geolocation data.

You need to specify the name, number of dimensions, the dimensions, type, and the num

```
% extracting info from dataset
[name_CTP,numdim_CTP,dimvector_CTP,type_CTP,numdescr] = hdfsd('getinfo', CTPid);
[name_lon,numdim_lon,dimvector_lon,type_lon,numdescr] = hdfsd('getinfo', longid);
[name_lat,numdim_lat,dimvector_lat,type_lat,numdescr] = hdfsd('getinfo', latid);
%
```

5) Reading the HDF datasets and importing into matlab

```
% Setting up vectors to read HDF datasets for importing into Matlab
startvector = [0 0];
endvector_CTP = dimvector_CTP;
endvector_lon = dimvector_lon;
endvector_lat = dimvector_lat;
stride = [];% stride — An array specifying the interval between the values to read
            % Default: 1, read every element of the data set.
```

6) Extracting the Lat, Long and CTP data and making it usable in Matlab

```
%Extracting the Lat, Long, and CTP data and making it usable
longvar = hdfsd('readdata', longid, startvector, stride, endvector_lon);% Long data out
latvar = hdfsd('readdata', latid, startvector, stride, endvector_lat);  % Lat data out
CTPvar = hdfsd('readdata', CTPid, startvector, stride, endvector_CTP);  % CTP data out
```

C1 (1.5 points) At this point you need to write your own code to deal with the CTP data (look to Lab 1 for ideas and code that you can use):

a) make CTP "double" do you can do mathematical fuctions

b) remove the "fill values" (not necessarily -9999, they will be different depending on the variable) and replace them with NaN.

c) apply the scaling factor and offset (if needed)

Hint: The (270,408) is related to the array size. Make sure to check what size each array is for each event. They are NOT the same and you'll need to change things in this section if you have to modify the longitude.

EXTRA INFO: Longitude would need further manipulation for southern hemisphere cases ONLY (which you won't be doing for this lab). In this case you would need to subtract 360 degrees from all values of longitude that are greater than 0 to remap on a linear scale. I wanted you to have the code if you needed it in the future.

```
% remapping on linear scale – going through sequentially by row and column
lon = zeros (270,408);  % row length, column length
for i=1:270             % from row 1 to row 270
    for j=1:408         % from columns 1 to column 208
        if longvar(i,j) > 0     % finding values greater than zero
            lon(i,j) =  longvar(i,j) - 360; % subtracting -360 to make it linear
        else lon(i,j) = longvar(i,j);       % renaming the variable to “lon”
        end
    end
end
%
```

8) Plotting – here you can use a similar method to what you did in Lab 1. This time we'll be using the function "contourf" and will use latvar for latitude, longvar for longitude and CTP for the variable. You will use latvar and longvar for northern hemisphere locations and would use the above code in the blue box if you had a southern hemisphere case to create a new longitude variabler called "lon"

Hints:

a) always start with "figure;" before your start your plotting code

b) contourf (latitude_variable_name, longitude_variable_name ,variable_name)

***Remember this is the structure, you have to change the variable names above to match the variable names you've chosen to use in the code above.*

c) set the axis to fit with the variable units. i.e. pressure can be from 100 hPa to 1000 hPa.

```
caxis ([100 1000])
```

***Remember you can check the unit range for each specific variable by using the quick view on the LAADS data site where you downloaded the .hdf file.*

d) use "`hold on`" **to add something other than the CTP countour**

e) to add a coastline (with a thick black line) without loading a separate file you can use:

```
load coast
plot(long, lat,'k','LineWidth',2)
hold off
```

f) Use the previous figure code from Lab 1 to add a title, xlabel, ylabel, and colorbar

After successfully creating the Cloud Top Pressure figure save it as a jpg.

g) you will notice that you have a mostly blank figure. Zoom in using the magnifying glass to the region with color. Jot down latitudes and longitudes that will allow you to focus on this particular region. Look to lab one for how to specify the axes using the function

axis([long_left long_right lat_bottom lat_top)];

Q2 – (2 points) Looking at the figure for CTP from 4-15-2010 make a statement discussing the major features by addressing the following: Can you use CTP to identify salient features from this event that you identified in the RGB? Make an estimate of the average CTP over Iceland. Make an estimate of the average CTP of the event, visible over the ocean in between Iceland and Europe. Can you tell if the event has a higher or lower cloud top pressure than background clouds? Why or Why not? Provide a potential explanation for your answer.

C2 – (6 points) Using the structure of the code above (and your additions) make a figure for the Cloud Top Temperature and Cloud Fraction Variable for the same day. You can simply add in new lines of code, that are identical in structure to those that reference CTP and modify them to access and reference the other variables. Save each figure as a jpg.

Q3 – (2.5 points) Looking at the figure for Cloud Top Temperature from 1-18-2003 can you identify the salient features using cloud top temperatures? What are the estimated mean cloud top temperatures over land and over the ocean? Does the event have a higher or lower cloud top temperature than the background clouds? How does this related to Cloud Top Pressure?

Q4 – (2.5 points) Looking at the figure for Cloud Fraction from 4-15-2010 can you identify the salient features using only cloud fraction? What are the estimated cloud fraction values over Iceland land and over the ocean between Iceland and Europe? Would you recommend this variable as a way to help identify what phenomena is represented?

C3 – (8 points) Using your previous code that successfully produced the CTP, CTT and CF figures do the same for the remaining 2 events (listed below). Make sure to save each figure as a jpg so you have one CTP, CTT and CF figure for each event. You can make 2 NEW separate codes and simply switch the file that you are loading, or write ONE LARGER Code. Either way works. It is totally up you to make that decision. In this step you will produce 6 images in addition to the 3 you previously made. Make sure to include the date and or the event name and the variable used in the figure title so you can keep track.

2) Date: August 1, 2013 Time: 1430 Day Number: 213
3) Date: November 2, 2013 Time: 0545 Day Number: 306

HINT: You have to make sure that the number of pixels array matches with each L2 file (270, 406) vs.(270, 408) if changing the longitude is necessary. Remember from lecture some of the Granules are a different size.

HINT: You may not have to modify the longitude. If the maps don't work, try using longvar (the original longitude instead of the -360 modified one) and commenting out with a % the "if" loop sequence. You only need to modify things if the event takes place in the Southern Hemisphere.

Q5 – (5 points) For each of the 3 events discuss which variable (CTP, CCTT or CF) helps you determine or identify the nature of the event best. Estimate the maximum and minimum values for CTP, CTT and CF for each of the "events" and the background clouds (not associated with the event) in each image. These are general averages, everyone may have slightly different values. Make a table to summarize these estimations (max, min, event, background) and the "best variable" option. NOTE: You may not be able to clearly see each feature, do your best! For example:

Date	CTP - event		CTP - bg		CTT - event		CTT - bg		CF - event		CF - bg		Best Var

3 USING MATLAB TO MAP L3 DAILY CLOUD PROPERTIES

1) For this portion you will be writing your own code to make global maps that are then "zoomed in" to focus on the regions identified in the L2 Granules.

C4 – (5 points) Using the techniques that you used in Lab 1 load the five L3 Daily data files (one for each event). You will end up with 6 figures at the end of this step.

a) load all five L3 the data files
b) extract CTP, CTT, and CF for each
c) makes sure to replace "fill values" with NaN
d) make sure to apply the necessary offsets and scaling factors
e) make figures (one each for CTP, CTT, and CF) that are "Zoomed In" to the L2 data.
f) use the "contourf" function to make the figure so you can make comparisons more easily.

****Hint: You can use the figures from L2 section to find the appropriate Latitude and Longitudes for your individual events.***

2) In this step you will be comparing the global daily average data (1°x 1°) to the 5 km data in the L2 images.

Q6 – (6 points) You have 3 events with 3 variables each.

a) Subjectively, how well does the L3 CTP represent the 3 events? Can you identify the features of each event at the lower resolution? Elaborate on the differences between the L2 and L3 retrievals. Are the CTP values higher or lower in the L3 figures as compared to L2?

b) Subjectively, how well does the L3 CTT represent the 5 events? Can you identify the features of each event at the lower resolution? Elaborate on the differences between the L2 and L3 retrievals. Are the CTT values higher or lower in the L3 figures as compared to L2?

c) Subjectively, how well does the L3 CF represent the 3 events? Can you identify the features of each event at the lower resolution? Elaborate on the differences between the L2 and L3 retrievals. Are the CF values higher or lower in the L3 figures as compared to L2?

Q7 – (4 points) Using what you have learned in Lecture, the Readings, and this Lab: Summarize the issues and assumptions that may limit the ability for the L3 products to accurately represent the events observed on the 3 selected days.

4 LAB REPORT WRITE UP

For this assignment provide the following in digital or paper format by next Friday, September 29th, 2017:

1) (2.5 points) A brief summary of the labs main goal
2) (25 points) Answers to questions Q1 through Q7 with References if needed.
3) (20.5 points) Coding questions C1 through C4 and the resuling (3 RGB images and 18 figures (9 L2, 9 L3)

Figure Presentation Note: For each event organize the L2 figures so you have 4 per page - RBG, CTP, CTT and CF. For L3 figures have 4 per page as well – RBG (L2) and the L3 CTP, CTT and CF. You should have 6 pages of figures. 3 pages for L2 Figures and 3 pages for L3.

4) (2 points) Copies of the code.