**NDVI Metrics Calculation Document**

**201201**

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This document describes the NDVI metrics algorithms and running environment of these programs. Programs are realized with IDL codes.

1. Directories and IDL startup file

The programs are resided in jzhu.gina.alaska.edu. The directories used to store different programs or data files are:

1. nps-cesu home directory: CESU\_NDVI=~/nps/cesu/modis\_ndvi\_250m

2. directory for scripts: $CESU\_NDVI/script

unzip\_ndvi.bash, and rename\_ndvi.bash are stored here.

3. work directory: $CESU\_NDVI/wrkdir

store unziped data files,immediate data files, and result data files.

4. idl programs directory: $CENSU\_NDVI/wrkdir/ndvi\_nps

You need set environment variable

Export IDL\_STARTUP=/home/jiang/nps/cesu/startup\_nps\_ndvi.pro

In startup\_nps\_ndvi.pro, you put one idl command to start envi:

ENVI, /RESTORE\_BASE\_SAVE\_FILES

PREF\_SET,’IDL\_PATH’,’<IDL\_DEFAULT>:+/home/jiang/nps/cesu/bin’, /COMMIT

5. raw zip ndvi data directory: ~/nps/cesu/modis\_ndvi\_250m/TERRA

B. The procedure of the data process:

1. unzip the ndvi files (~nps/cesu/script)

The ndvi files come from EMODIS website. They are zip files. First, download them and store them ~/nps/cesu/modis\_ndvi\_250m/TERRA. Then unzip and rename them by using scripts "unzip\_ndvi.bash" and "rename\_ndvi.bash", respectively.

2. stack and subset 7-day composite ndvi and classification data

Program: oneyear\_data\_layer\_subset\_good\_ver9.pro

inputs: flist\_ndvi, flist\_bq, ul\_lon,ul\_lat, lr\_lon, lr\_lat

flist\_ndvi includes 7-day ndvi file names of one year. flist\_bq includes 7-day ndvi\_bq file names of the same year.

subroutines: start\_batch.pro, read\_ndvi\_ver9.pro

outputs: yyyy\_oneyear\_layer\_subset\_good file. This file includes stacked ndvi and classification data of one year.

3. calculate one-year metrics and produce one-year smoothed data

Program: smooth\_calculate\_metrics\_tile\_ver9.pro

inputs: yyyy\_oneyear\_layer\_subset\_good file

subroutines: start\_batch.pro, time\_series\_process\_nps\_oneyear\_ver9.pro, interpol\_noextension\_1y\_vector\_ver10.pro, cutoff\_interp\_ver9.pro, oneyear\_extension100b.pro, user\_metrics\_nps.pro, wls\_smooth.pro

outputs: a metrics data file and a smoothed data file.

C. list of the program files

smooth\_calculate\_metrics\_tile.pro, time\_series\_process\_nps\_oneyear\_ver9.pro, layer\_stack.pro, oneyear.pro, oneyear\_data\_layer\_subset\_good.pro, interpol\_noextension\_1y\_vector\_ver9.pro, read\_ndvi.pro, start\_batch.pro, subset.pro, user\_metrics\_nps.pro, cutoff\_interp\_ver9.pro, wls\_smooth.pro, startup\_env.pro

D. data formats in different stages of process

1. The raw data comes from EMODIS. I use two kinds of files to produce ndvi metrics. One is 250m\_compisit\_ndvi.tif and other is 250m\_composit\_ndvi\_bq.tif. The data range in ndvi.tif is -1999 to 10,000, -2000 is fill value, and the scale factor is 0.0001. Data in ndvi\_bq.tif includes flag information. It indicates the type of the pixels. Types of the pixels are cloud, snow, fog, etc.

2. First, we process one pair of ndvi and ndvi\_bq files. We convert the data into 0 to 200 byte data by using the formula y=byte(x/100.0+100). In the new data, valid ndvi values are in the range of 100 to 200. The fill values (-2000) are converted into 80b. We store both ndvi data and pixel type data together.

3. Stack one year of 7-daycomposite data into a one year data file. The result file is named as yyyy\_oneyear\_layer\_subset\_good.tif (data range is 0 to 200, and data include 46 bands).

4. Combine the year before, the year, and the year after data files into a multiple-year data file. The program layer\_stack.pro finishes this process and produced a 3-year stacked data file named yyyy\_multiyear\_layer\_subset\_good (data range is 0 to 200, and data include 42 bands).

5. Smooth the multiple year stacked data and calculate the metrics of the year. The result data file is named as yyyy\_multiyear\_layer\_subset\_good\_smooth (data range is 0 to 200), and the metrics data is named as yyyy\_multiyear\_layer\_subset\_good\_metric (data include 12 bands).

E. detailed description of the algorithms

1. stack and combines one year ndvi and quality data together (oneyear\_data\_layer\_subset\_good\_ver9.pro)

I=i+1

Read ndvi\_file\_list and bq\_file\_list files into two arraries; set num\_of\_files=total number of files in the ndvi\_file\_list; i=0

Inputs: ndvi\_file\_list, bq\_file\_list, ul\_lon,ul\_lat,lr\_lon,lr\_lat

I is less than num\_of\_files

Stack the one-year ndvi and quality data together and output the data to a file

Read the i th ndvi file and bq file pair, subset them as required, and output the file descriptors (read\_ndvi\_ver9.pro)

the flowchart of oneyear\_data\_layer\_subset\_good\_ver9.pro

Read\_ndvi\_ver9.pro

a. It reads one pair of file (a ndvi file and its related ndvi quality file) into memory. Ndvi data are stored in data1(ns,nl), and ndvi quality flag data are stored in data2(ns,nl).

b. convert the NDVI value of the pixel from range -4000 to 10,000 (integer) into range 0 to 200 (byte) by using equation out=byte(in/100 +100).

c. stack the data1 and data2 together to form a two bands data(ns,nl,2). Band1 are data1 and band2 are data2.

1. Smooth and calculation metrics (smooth\_calculation\_metrics\_tile\_ver9.pro)

After stacking one year of ndvi data files (46 files per year) and converting the ndvi data range from -10,000 to 10,000 into 0b to 200b, we get a three dimension matrix (samples, lines, and bands). Each pixel corresponds to a 46- point of time-series vector.

The smooth\_calculation\_metrics\_tile\_ver9.pro does smoothing and calculating the metrics.

The relation among smooth\_calculation\_metrics\_tile\_ver9.pro and its subroutines is illustrated in Figure 2.

Smooth\_calculation\_metrics\_tile\_ver9.pro

Time\_series\_process\_nps\_oneyear\_ver9.pro

Interpol\_noextension\_1y\_vector\_ver9.pro

Wls\_smooth.pro

User\_metrics\_nps\_by1yr.pro

Computemetrics\_by1yr.pro

Cutoff\_interp\_ver10.pro

Getcrossover\_percentage\_extremeslope\_ver15.pro

Getsos\_ver16.pro

Interpol\_line100b.pro

Filter\_2odd.pro

Geteos\_ver16.pro

Findday.pro

Getforwardma.pro

Getbackwardma.pro

Getmaxndvi.pro

Gettondvi.pro

Getndvitodate.pro

Getslope.pro

Getrange.pro

The smooth\_calculation\_metrics\_tile\_ver9.pro reads the time-series of every pixel, calls time\_series\_process\_nps\_oneyear\_ver9.pro to smooth the time-series and calculate the metrics of the pixel.

For each time-series, the time\_series\_nps\_oneyear\_ver9.pro does three steps: interpolate the time series, smooth the time series, and calculate the metrics of the time series.

The interpol\_noextension\_1y\_vector\_ver9.pro interpolates the time series.

The flowchart of the interpolation process is illustrated in Figure 3.

Read the time series (includes: ndvi, pixel type) and brand name

Calculate the up-threshold point and down-threshold point. Assign the negative points or bad points with randomly 100b or101b for the time series. Separate the time series into 3 segments. Interpolate fill points for the middle segment.

Are all points fill or the number of valid points is less than 5 or the greatest normalized ndvi ( 0 to 1) is less than 0.25?

Interpolate one or two consecutive odd points

Return interolated ndvi, interpolated pixel type, and interpolated band name, metrics\_calculation\_flag

Flg\_metrics=0

Flg\_metrics=1

Yes

no

Figure 3. The flowchart of interpolation

In eMODIS ndvi data, each pixel is classified as 6 types, such as: 0-good, 1-cloudy, 2-bad, 3-negative reflectance, 4-snow, and 10-fill, and ndvi have both positive and negative values.

After the time series is interpolate and smoothed by wls\_smooth.pro, the time series is used to calculate the metrics by the computemetrics\_by1yr.pro.

The flowchart of calculation of metrics is illustrated in Figure 4.

Inputs: smoothed\_ndvi, pixel type, bandname

calculate the forward moving average (fwa); get the up-crossover points that the smoothed\_ndvi crossover from below to forward moving average vector, up-threshold points, and first maximum value points; use first up-threshold point as a possible SOS point (sos\_p1), pick the point in the up-crossover points, which is most closed to sos\_p1 as another possible SOS (sos\_p2), pick the point, between sos\_p1 and sos\_p2, with the greater index as sos\_p3, make look for the point which is after sos\_p3 point and is not snow as SOS point.

Calculate the backward moving average (bma); get the down-crossover points that the smooth\_ndvi crossover from above to backward moving average vector, down-threshold points, and last maximum point; use last down-threshold point as a possible EOS point (eos\_p1), pick the point in the down-crossover points, which is most closed to eos\_p1 as another possible EOS (eos\_p2), pick the point, between eos\_p1 and eos\_p2, with the smaller index as eos\_p3, make look for the point which is before eos\_p3 point and is not snow as EOS point.

Find the end of greenness point: do the similar process as “find the onset point”, except we get the crossover points by letting the smoothed\_v crossover the backward moving average from above.

Calculate other metrics items such as slope, range,etc.

return metrics\_v

Figure 4 NDVI metrics algorithm flowchart