Land Cover Product Derivation from AVHRR HRPT Data for Numerical Weather Prediction Models: Using ENVI in Batch Mode

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ABSTRACT

Near surface meteorological variables such as 2-m temperatures and relative humidity and 10-m winds are strongly influenced by the condition of the land surface. Land surface characteristics such as fractional vegetation cover (fVEG) and leaf area index (LAI) are among the most important parameters needed for improving numerical weather prediction modeling.

For daily forecasts, such variables must be available in near-real time. We demonstrate a procedure for rapidly estimating fVEG and LAI from direct-downloaded NOAA AVHRR HRPT data using the ENVI image analysis software operating in batch mode. HRPT data are downloaded to a receiving station in Lincoln, Nebraska.

The processing stream provides for reading level-1b data, generation of the Normalized Difference Vegetation Index (NDVI), geometric correction, mosaicking and sub-setting imagery. Procedures for LAI and fVEG product generation facilitate use of ancillary data such as the USGS National Land Cover Dataset (NLCD).

Land surface products are delivered via FTP to the SSL.

Preliminary evaluation indicates that the procedures perform well using ENVI as a complete programming platform for development of *ad-hoc* applications.

WHY ENVI IN BATCH MODE?

ENVI in batch mode was used for automation of the process of generating free cloud NDVI composites during 15 day periods. Use of ENVI in batch mode offers routines for image processing and specifically for AVHRR data management (calibration and geo-reference).

Since ENVI was written in Interactive Data Language (IDL) which is a powerful structured programming language with integrated image processing, it is possible to use IDL routines at the same time for files and character strings management, loops, conditionals among others.

A suite of routines called *"do_it"* for batch processing are available in ENVI. In this case only those for NDVI calculation, geometric correction and mosaicking were used.

Batch routines take either a single or a group of files and perform a set of tasks. All the parameters for the processing routine can be specified without user interaction and the result from a processing step can be used as input for the next step.

STUDY AREA

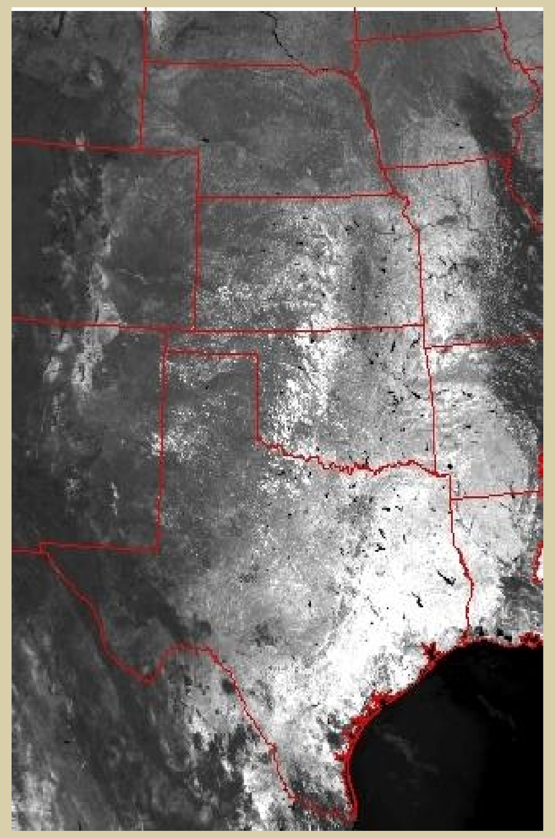

Figure 1. Study Area

A) NDVI CALCULATION AND GEOREFERENCE

Figure 2. NDVI from the first pass raw image

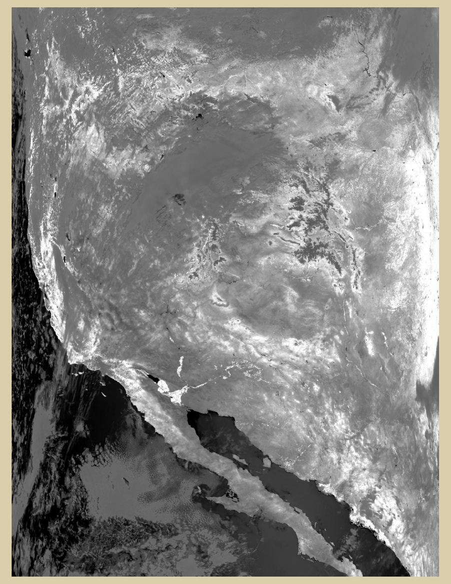

Figure 3. NDVI from the second pass raw image

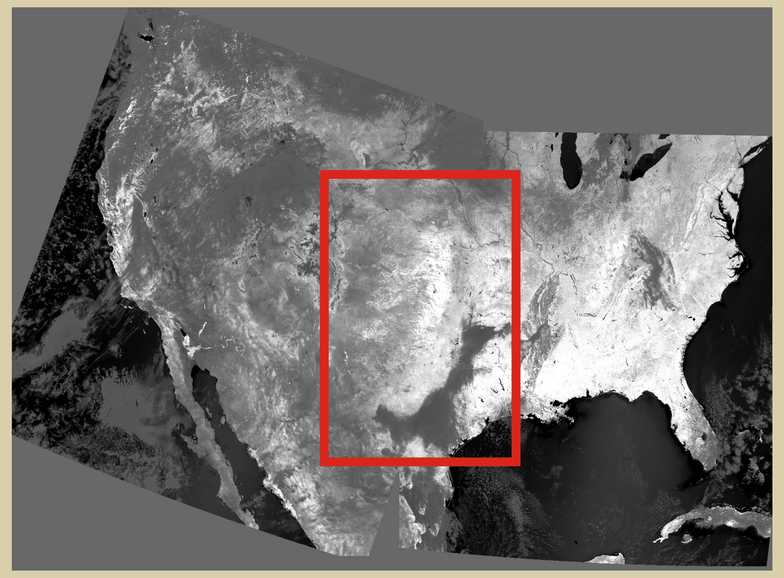

Figure 4. Rectified mosaic from two consecutive satellite passes

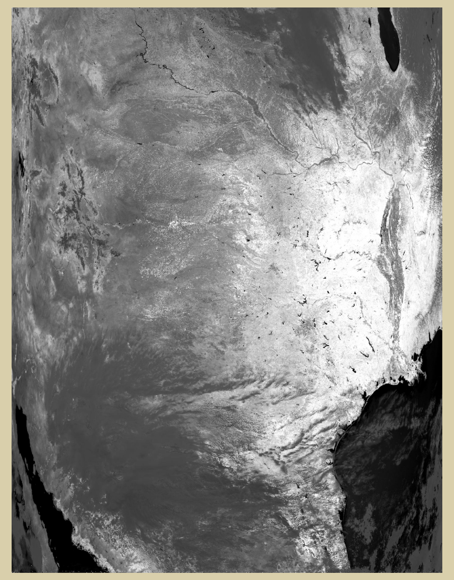

Figure 5. NDVI from a full raw pass

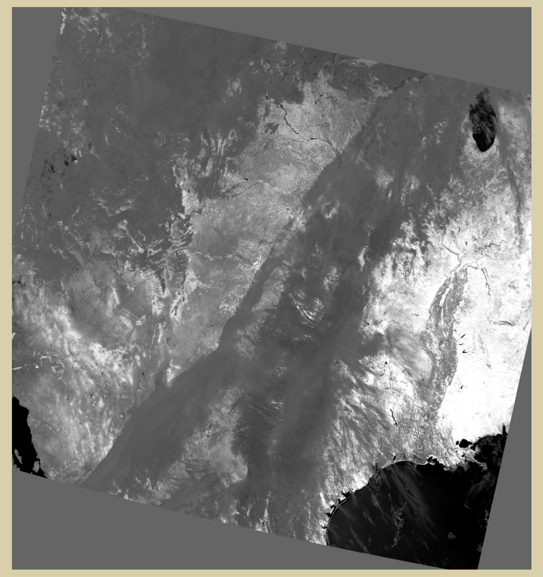

Figure 6. Subset from a rectified NDVI (one day image)

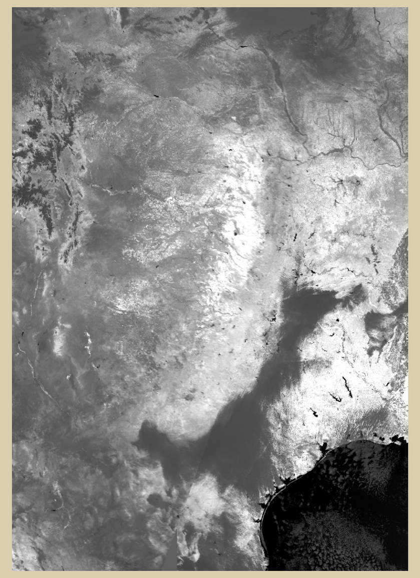

Figure 7. Subset to the area of Interest

A) a. The ENVI *NDVI_DOIT* subroutine calculates the NDVI from the imported .11b HRPT data. Each image is geometrically corrected using a Lambert Azimuthal projection. Geo-referencing in ENVI utilizes geo-location data embedded in the AVHRR Level 1b data file. The level 1b file contains 51 geo-location points for every line of the image.

If more than one pass is needed to cover the region of interest (see early pass Figure 2 and late pass Figure 3), first the subroutine (*WARP_DOIT*) is called for geometric rectification and then the *MOSAIC_DOIT* subroutine is called in order to mosaic the images.

A) b. The mosaicking process uses a binary subroutine available from the RSI's contributed software site (*GEOREF_MOSAIC_SETUP*). This is used to calculate the new map extent based on map coordinates instead of file coordinates.

A) c. If with one satellite pass the area of interest is covered, then the geometric rectification subroutine is called and then subset the study area for the next process

A) d. Finally a subset of the study area is generated for the next process.

B) MAXIMUM AND MINIMUM CALCULATION

Figure 8. Stacked 15 days NDVI

B) Between 10 and 15 daily images (some days are not available due to mis-registration or noisy data) are stacked and then the maximum NDVI (Figure 10) cloud free composite, and minimum NDVI (Figure 11) for the series are calculated. Estimation of LAI requires a maximum and minimum NDVI for the growing season at each pixel location. A12 year period of NDVI data from the USGS/EROS Data Center is used to compute the maximum maximorum and a minimum minimorum. These are employed to estimate the maximum and minimum values for the observed period.

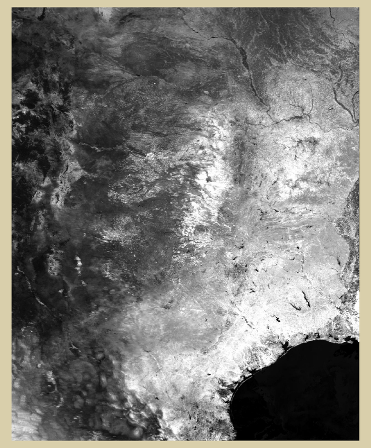

Figure 9. Maximum NDVI.

Figure 10. Minimum NDVI

C) BIOPHYSICAL VARIABLES CALCULATION

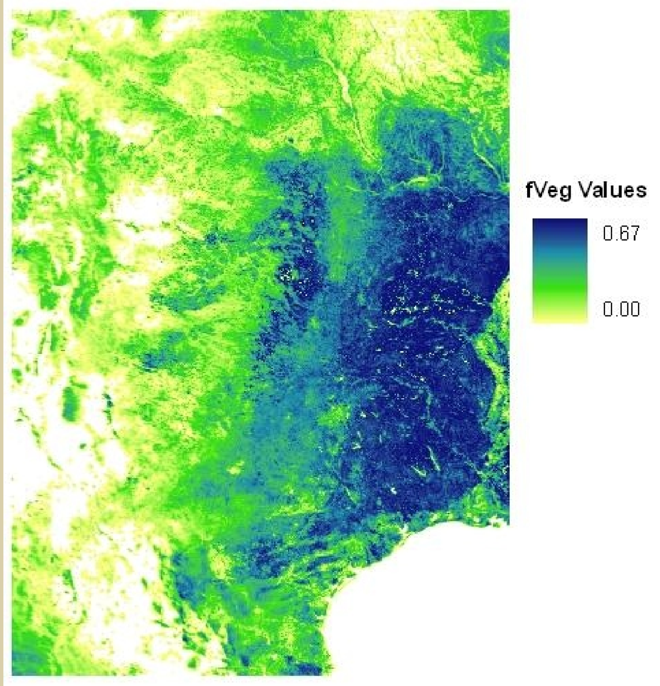

Figure 11. fVEG April 01- 15 2004

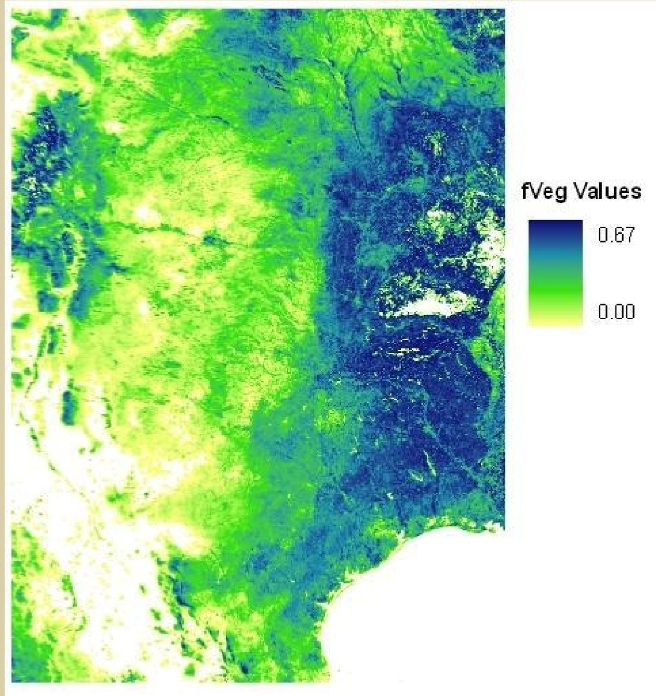

Figure 12. fVEG June 01- 15 2004

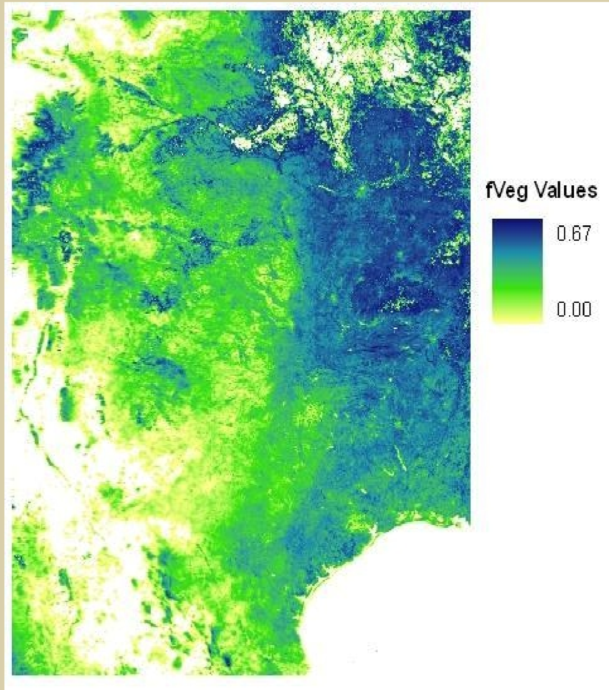

Figure 13. fVEG July 16- 31 2004

FVEG is calculated using the formula proposed by Chang and Wetzel (1991)

FVEG = 1.5(NDVI - 0.1), NDVI <= 0.547
3.2(NDVI) - 1.08, NDVI > 0.547

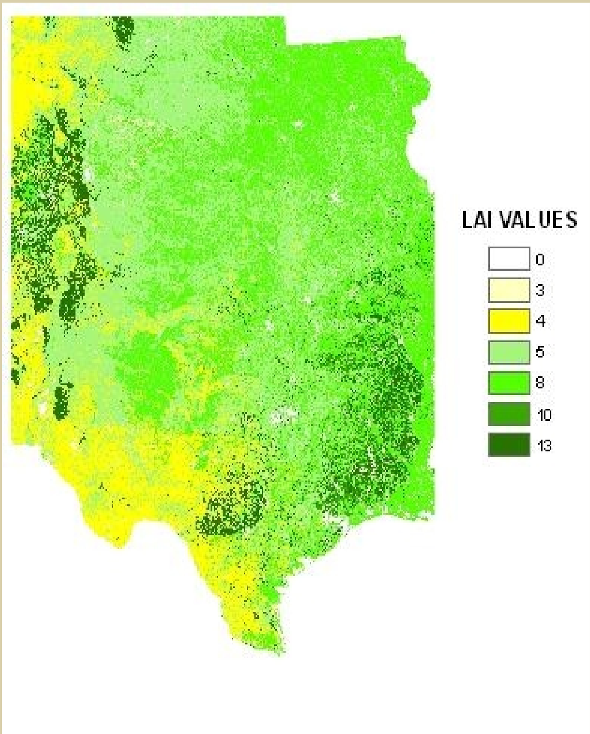

Figure 14. Maximum LAI

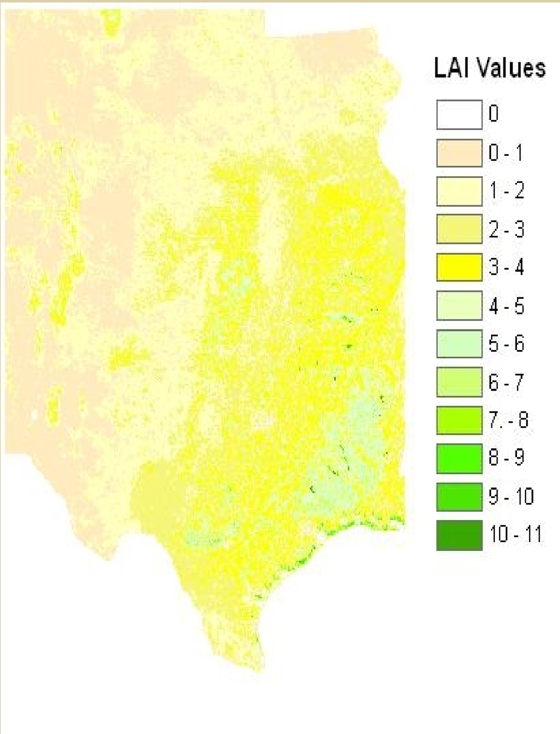

Figure 15. LAI April 01-15 2004

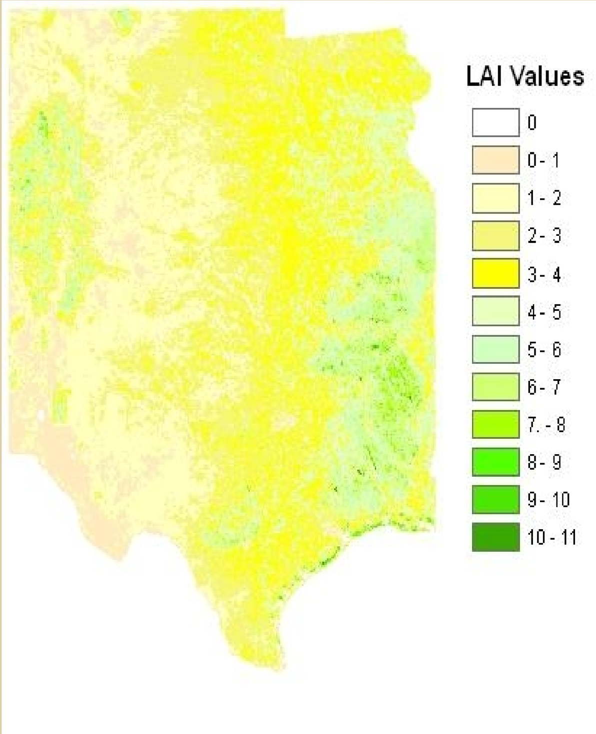

Figure 16. LAI June 01-15 2004

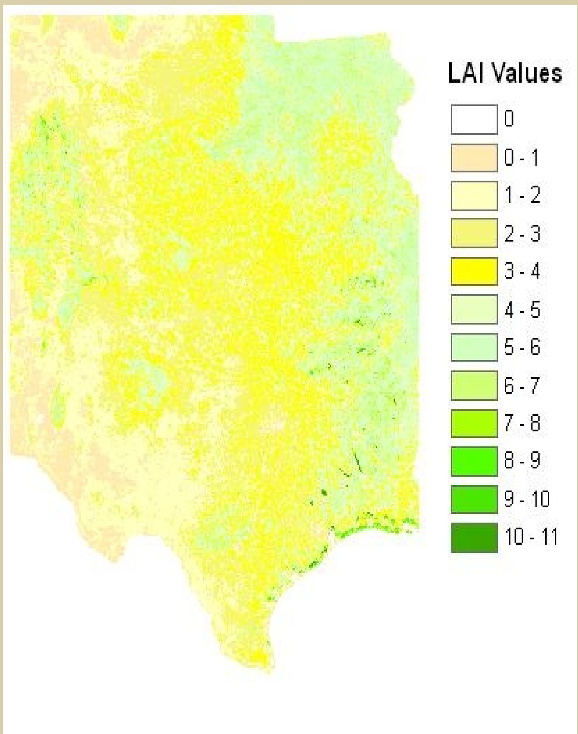

Figure 17. LAI July 16-31 2004

The LAI is estimated using methods suggested by Ying and Williams (1991)

LAI= LAImax * (NDVI - NDVImax) / (NDVImax - NDVImin)

A maximum LAI dataset was developed using the USGS National Land Cover Dataset (NLCD). The NLCD was derived from 1992-2003 Landsat TM using a modified Anderson level II (Collin et all 2001). The NLCD data were downloaded from the USGS/EROS Data Center, mosaicked, resampled from 30m to a 1-km cell size and subset to the area of interest. The maximum LAI value was set for each land cover using the Global Leaf Area Index Data from field measurements 1932-2000 (Scurlock et al. 2001) available on line through <http://eee.daac.ornl.gov>

CONCLUSIONS AND FUTURE WORK

ENVI operating in batch mode is a very flexible and powerful tool for fast computation of key variables needed for characterizing the land surface in near-real time as required for numerical weather forecast models.

The use of specific AVHRR and IDL (Interactive Data Language) allows to handle this type of imagery in a very straight forward manner in order to automate the process of produce LAI and fVEG products.

Further analysis for the incorporation of this type of biophysical variables to the NWPM (Numerical Weather Prediction Models) requires the calculation of LAI and fVEG over a shorter time window. Evaluation of cloud masked daily NDVI is currently being undertaken as a way to build a set of decision rules using ENVI's decision tree tool.

REFERENCES:

Collin et al. National Land Cover Characterization 2001 (NLCD 2001). 20 Oct. 2003. 1Nov. 200,3 <http://landcover.usgs.gov/ natlandcover_2000.asp>

Chang J.T. and P.J. Wetzel 1997 Effects of spatial variation of soil moisture and vegetation on the evolution of a prestorm environment: A numerical case study. *Monthly Weather Review* 119: 1386-1390

Scurlock, J. M. O., G. P. Asner, and S. T. Gower. 2001. Global Leaf Area Index Data from Field Measurements, 1932-2000. Data set. Available on-line <http://www.daac.ornl.gov> from the Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

Ying and Williams, 1997 Obtaining spatial and temporal vegetation data from Landsat MSS and AVHRR/NOAA satellite images for a hydrologic model. *Photogr. Eng. Remote Sens*. 63:69-77

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