EVI-based Green Vegetation Fraction Derived from Suomi NPP VIIRS

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1. Introduction

A new Green Vegetation Fraction (GVF) operational product system is currently being developed and transitioned to operations at STAR (Center for Satellite Applications and Research). The new system is to produce GVF as a NOAA-Unique Product (NUP) from the Visible Infrared Imager Radiometer Suite (VIIRS) sensor onboard the Suomi National Polar-orbiting Partnership (S-NPP) satellite launched in late 2011, for applications in numerical weather and seasonal climate prediction models at the National Centers for Environmental Prediction (NCEP). The new GVF from S-NPP VIIRS will provide continuity for the current AVHRR-based GVF system and improved spatial and temporal resolution. The new retrieval algorithm uses the following VIIRS top of the canopy (TOC) reflectance bands as input: red (I1), near-infrared (I2), and blue (M3) bands centered at 0.640 μm, 0.865 μm and 0.490 μm respectively. In the new system, the Enhanced Vegetation Index (EVI) is calculated from the three bands and used to derive GVF; this approach is different from the current NOAA operational GVF system which uses AVHRR top of the atmosphere (TOA) reflectance bands to produce NDVI which is subsequently used as input to the GVF algorithm. The new GVF will be produced on a daily rolling weekly basis at nominal 4-km resolution (global scale) and 1-km resolution (regional scale).

2. Data and Methods

The GVF is produced on a daily rolling weekly basis. Each day the VIIRS surface reflectance of the past 7 days is composited into a weekly surface reflectance composite, using a maximum value compositing method which selects pixels unbiased with respect to forward-backward scattering directions and avoids high view zenith angles. EVI is computed from the weekly composite and temporally filtered using an EVI time series consisting of the current weekly EVI and the past 14 weeks' EVI to fill the gaps and remove the noise in the current weekly EVI. GVF is calculated from the filtered EVI and aggregated to the desired spatial resolutions. The major steps are described blow.

2.1. Gridding of the daily VIIRS surface reflectance

The GVF processing is performed in a latitude-longitude grid system with 0.003° resolution. The GVF grid system is divided into square tiles, each of which is represented as a file, to accommodate the file and memory size constraint of computers and facilitate parallel computing spatially. Water pixels and cloud pixels are discarded in the gridding process. All subsequent intermediate processing is conducted in tiles and at 0.003° resolution. The figure below shows the gridded surface reflectance from the granules of the same satellite orbit over non-clouded areas of North America.

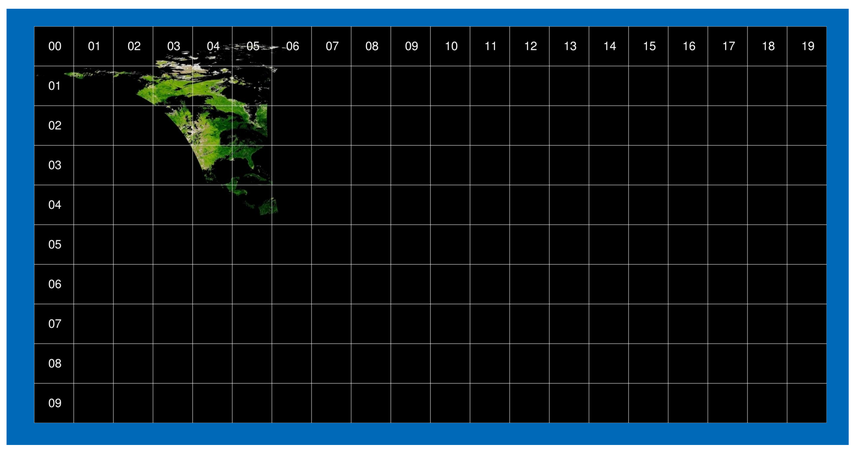


Figure Caption:
The gridding of surface reflectance from granules of the same satellite orbit over North America into multiple GVF tiles. Each tile has a 18° x 18° dimension and a pixel size 0.003°. Water and clouded areas have no surface reflectance data and are shown in black.

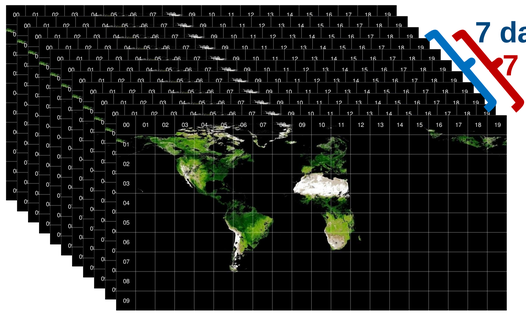
2.2. Weekly compositing of the gridded daily VIIRS surface reflectance

Conventional maximum NDVI value compositing selects more pixels in the forward scatter direction, and occasionally at high view zenith angles. To overcome these problems, this work adopts a compositing methodology developed by Jiang et al, 2012 (submitted to ISPRS P&RS) which uses a maximum View-angle Adjusted SAVI (VA-SAVI) value compositing. VA-SAVI is computed as:

$$VA-SAVI = SAVI - C \times VZ^2$$

in which, SAVI is defined as $SAVI = (1+0.05)\frac{NIR-red}{NIR+red+0.05}$

C is a per-pixel coefficient derived from the SAVI values in the compositing period (i.e., 7 days), and ***VZ*** is view zenith angle.



Each day for each pixel location in a tile, the observation with the maximum VA-SAVI value from the past 7 days is selected in compositing. The daily rolling weekly scheme is shown in the left figure.

2.3. EVI calculation and filtering

EVI is computed from the daily rolling weekly surface reflectance composite as $EVI = 2.5\frac{NIR-red}{NIR+6\,red-7.5\,blue+1}$

The weekly EVI is then temporally filtered (*Velleman and Hoaglin, 1981, Applications, basics and computing of exploratory data analysis*) using an EVI time series consisting of the current weekly EVI and the past 14 weeks' EVI to fill the gaps and remove the noise in the current weekly EVI. This filtering also updates the EVI estimate for middle of the time series (i.e. initially estimated 7 weeks prior).

2.4. GVF calculation and aggregation

GVF is calculated from the smooth EVI as: $GVF = \frac{EVI - EVI_{\min}}{EVI_{\max} - EVI_{\min}}$

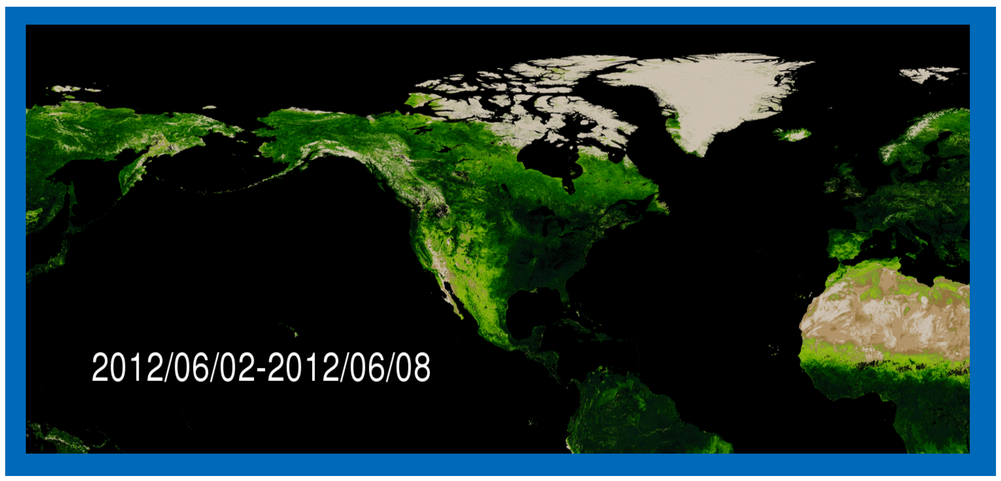
in which EVI_{min} and EVI_{max} are the 5 and 95 percentile of global EVI values. Currently we use EVI_{min} = 0.0602, EVI_{max} = 0.5707. When more VIIRS data is accumulated, these extreme values will be updated.

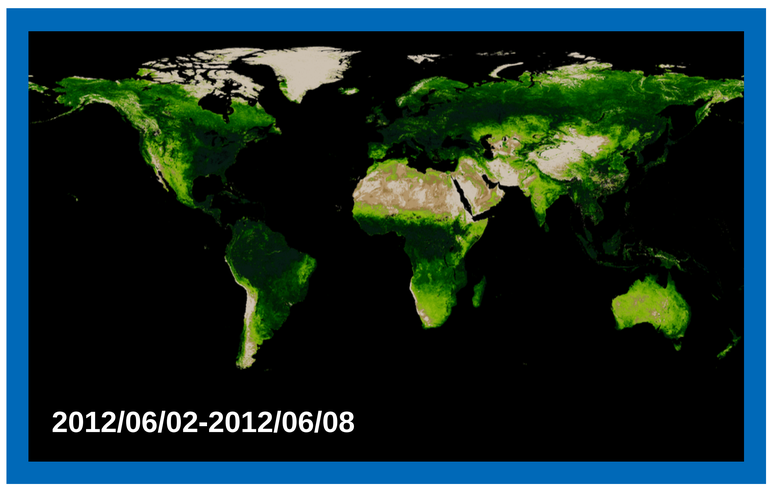
The 0.003° resolution GVF is 12 x12 aggregated into the global scale GVF (nominal 4-km), and 3 x 3 into a regional product (nominal 1-km) centered in North America to be used in NOAA NCEP meso-scale weather models.

3. Sample Results

Initial GVF results using the VIIRS surface reflectance from June 02, 2012 to June 08, 2012 at the regional scale and global scale are illustrated below, with darker green representing high GVF values. The GVF captures the greenness at global scale.

Figure Caption:
Regional product for latitude -7.5° to 90° and longitude 130° eastward to 30° at nominal 1-km resolution (0.009 °). There are 108334 x 28889 pixels in the image.





This VIIRS GVF product will be validated using land cover data derived from medium resolution satellite data such as Landsat. The sensitivity of weather models to GVF characterization will be evaluated in future work.

Figure Caption:
Global product at nominal 4-km resolution (0.0036 °). There are 10000 x 5000 pixels in the image.

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