Developing a compositing algorithm for retrieval of green vegetation fraction

Zhangyan Jiang[12], Junchang Ju[12], Marco Vargas[1], Ivan Csiszar[1]

[1] NOAA National Environmental Satellite, Data, and Information Service, Center for Satellite Applications and Research, College Park, MD, 20740. [2] AER inc. Lexington, MA, 02421

Introduction

Green Vegetation fraction (GVF) is defined as the fraction of a pixel covered by green vegetation if it were viewed vertically. It is used to separate vegetation and soil in energy balance processes, including temperature and evapo-transpiration. Real-time weekly global GVF is needed in the numeric weather, climate and hydrological models. The current NOAA operational GVF product is derived from weekly AVHRR NDVI, which is composited using the maximum-value compositing (MVC) method. Although MVC is a widely used technique to remove cloud and atmospheric contamination by selecting the observation with the maximum NDVI value, it is well documented that the maximum NDVI is often selected from the high sensor zenith angles by MVC, which may introduce errors in GVF retrieval. To select high quality observations close to the nadir view, a Maximum View angle Adjusted SAVI (MVA-SAVI) compositing algorithm is developed. It needs only SAVI and view zenith angle information in compositing. It is evaluated and compared with other compositing algorithms, including MVC, the MODIS vegetation index compositing algorithm and the MODIS 8-day surface reflectance compositing algorithm. The new compositing technique is being used in a new GVF product from Suomi NPP VIIRS, that is currently being transitioned from research to operation.

Method and data

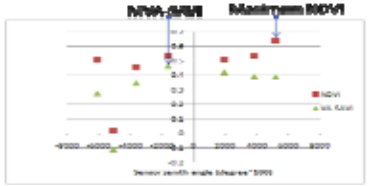
MVC favors observations in the forward scatter direction. To reduce the bias in view angle directions, Jiang et al (2012, submitted to ISPRS P&RS) proposed using the soil-adjusted vegetation index (SAVI) , instead of NDVI, in compositing.

$$SAVI = (1+L)\frac{NIR - \mathrm{Re}d}{NIR + \mathrm{Re}d + L}$$

SAVI increases with the increase of view zenith (VZ) angles due to surface BRDF effects. VZ should be taken into account in compositing such that observations close to the nadir view are given a priority under clear sky conditions and observations at off-nadir view should be selected only if nadir view observations are cloudy. So, in compositing, SAVI should be adjusted according to its VZ angle for each observation. The View-angle Adjusted SAVI (VA-SAVI) is designed as:

$$\text{VA-SAVI} = \text{SAVI} - C \times VZ^2$$

Where C is a coefficient. The Maximum VA-SAVI (MVA-SAVI) observation in a compositing period, instead of the maximum NDVI, is selected to represent the compositing period.



Compositing

MODIS Aqua 500-m daily surface reflectance MYD09GA are composited by the MVA-SAVI and MVC algorithms. NDVI and Enhanced vegetation index (EVI) are calculated.

$$NDVI = \frac{NIR - \mathrm{Re}d}{NIR + \mathrm{Re}d} \qquad EVI = 2.5\frac{NIR - \mathrm{Re}d}{NIR + 6\,\mathrm{Re}d - 7.5Blue + 1}$$

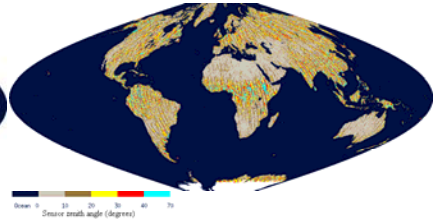
MVA-SAVI composite maps are compared with

1. MVC composite data
2. MODIS Aqua 500-m 16-day vegetation index product (MYD13A1)
3. MODIS Aqua 500-m 8-day composite surface reflectance product (MYD09A1).

Results

A. MVA-SAVI composite maps

16-day MVA-SAVI composite NDVI 2006-217



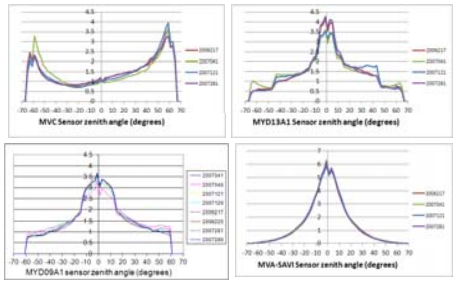
16-day MVA-SAVI composite sensor zenith angle 2006-217

16-day MVA-SAVI composite EVI 2006-217

- ❑ 76% sensor zenith angles < 20°
- ❑ 89% sensor zenith angles <30°
- ❑ Low sensor zenith angle observations are selected by MVA-SAVI
- ❑ High (not necessary maximum) NDVI and EVI values are retained

B. Comparison with MVC, MYD13A1 and MYD09A1 data

Histograms of sensor zenith angles



•MVA-SAVI Sensor zenith angles distribute normally and are close to the nadir view

Comparison pixel-by-pixel

- **Case 1**: MVA-SAVI selects the **same** sensor zenith angle as other compositing algorithms do
- **Case 2**: MVA-SAVI selects a **smaller** sensor zenith angle than other compositing algorithms do
- **Case 3**: MVA-SAVI selects a **greater** sensor zenith angle than other compositing algorithms do

Comparison of 16-day MVA-SAVI and MVC composite data

	Percent pixels (%)	Data	Mean sensor zenith angle (degrees)	Mean NDVI	Mean EVI
Case 1	30.9	MVA-SAVI	20.0	0.519	0.316
		MYD09A1	20.0	0.519	0.316
Case 2	68.6	MVA-SAVI	10.5	0.338	0.208
		MYD09A1	48.1	0.380	0.219
		Percent difference (%)	-78.1	-11.2	-4.9
Case 3	0.5	MVA-SAVI	24.3	0.636	0.380
		MYD09A1	15.9	0.680	0.230
		Percent difference (%)	52.9	-6.5	65.4
All	100.0	MVA-SAVI	13.5	0.395	0.243
		MYD09A1	39.3	0.425	0.249
		Percent difference (%)	-65.6	-6.9	-2.7

Percent difference (%)= 100(MVA-SAVI-MVC)/MVC

(a) Compared with MVC, MVA-SAVI

- Reduced sensor zenith angles by 65.6%
- Decreased NDVI values by 6.9%
- Decreased EVI values by 2.7%

Comparison of 16-day MVA-SAVI and MYD13A1 composite data

	Percent pixels (%)	Data	Mean sensor zenith angle (degrees)	Mean NDVI	Mean EVI
Case 1	47.0	MVA-SAVI	13.7	0.438	0.261
		MYD09A1	14.1	0.438	0.264
Case 2	42.2	MVA-SAVI	11.4	0.339	0.210
		MYD09A1	37.6	0.333	0.198
		Percent difference (%)	-69.6	1.6	6.3
Case 3	10.8	MVA-SAVI	20.9	0.441	0.262
		MYD09A1	10.8	0.376	0.214
		Percent difference (%)	94.1	17.4	22.6
All	100.0	MVA-SAVI	13.5	0.395	0.239
		MYD09A1	23.7	0.386	0.230
		Percent difference (%)	-42.9	2.4	3.8

Comparison of 8-day MVA-SAVI composite and MYD09A1 data

	Percent pixels (%)	Data	Mean sensor zenith angle (degrees)	Mean NDVI	Mean EVI
Case 1	60.2	MVA-SAVI	16.6	0.397	0.242
		MYD09A1	16.6	0.397	0.242
Case 2	28.4	MVA-SAVI	13.2	0.286	0.184
		MYD09A1	38.8	0.275	0.170
		Percent difference (%)	-66.0	4.0	8.4
Case 3	11.3	MVA-SAVI	27.0	0.378	0.236
		MYD09A1	13.9	0.270	0.164
		Percent difference (%)	94.4	40.2	43.5
All	100	MVA-SAVI	16.8	0.362	0.224
		MYD09A1	22.6	0.347	0.212
		Percent difference (%)	-25.9	4.4	5.7

Percent difference (%)= 100(MVA-SAVI-MYD09)/MYD09

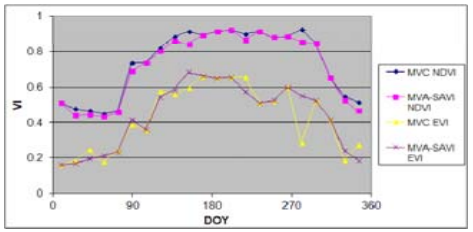
(b) Compared with MYD13A1, MVA-SAVI

- Reduced sensor zenith angles by 42.9%
- Increased NDVI and EVI slightly

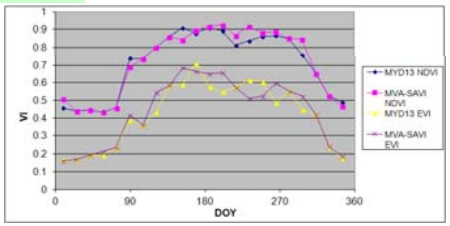
(c) Compared with MYD09A1, MVA-SAVI

- Reduced sensor zenith angles by 25.9%
- Increased NDVI values by 4.4%
- Increased EVI values by 5.7%

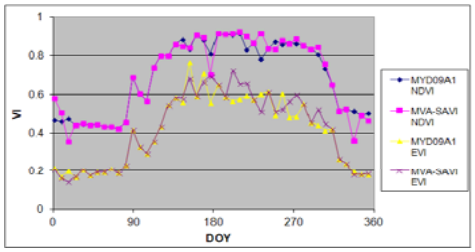
C. Time series comparison at Walker Branch (Broadleaf Forest)



➢EVI time series by MVA-SAVI are smoother than MVC EVI time series



➢NDVI and EVI time series by MVA-SAVI are higher than MYD13 time series in peak season



➢EVI time series by MVA-SAVI are higher than MYD09A1 EVI time series

Conclusions

- ▪MVA-SAVI compositing algorithm was designed to select high quality observations from low view zenith angles (mostly less than 20°) to ensure GVF is measured vertically.
- ▪Compared with MVC, MVA-SAVI reduced sensor zenith angles significantly
- ▪Compared with MOD13A1 and MYD09A1, MVA-SAVI reduced sensor zenith angles and increase vegetation index values slightly, indicating better compositing performance
- ▪MVA-SAVI is a simple and effective compositing algorithm, which needs only SAVI and sensor zenith angles, independent of Quality flags, and can be used to compositing AVHRR data

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