Validation of VIIRS Vegetation Index EDR Using In Situ Radiation Sensor Data

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Introduction

Satellite vegetation index time series datasets have been used to monitor and characterize seasonal vegetation dynamics in regional to global scales. Visible Infrared Imaging Radiometer Suite (VIIRS) Environmental Data Records (EDR) include two vegetation index (VI) products: Top of the Atmosphere (TOA) **Normalized Difference Vegetation Index (NDVI)** and the Top of the Canopy (TOC) **Enhanced Vegetation Index (EVI)**. Validation of the VI EDR is critical to assure product accuracy and consistency throughout the mission. Ground observation networks are emerging, providing well-calibrated time series measurements at high temporal resolution and data availability, as well as covering a wide range of vegetation types and climates. FLUXNET includes over 500 towers worldwide. Some towers are mounted with sensors measuring radiation which can be processed into VIs.

Objectives

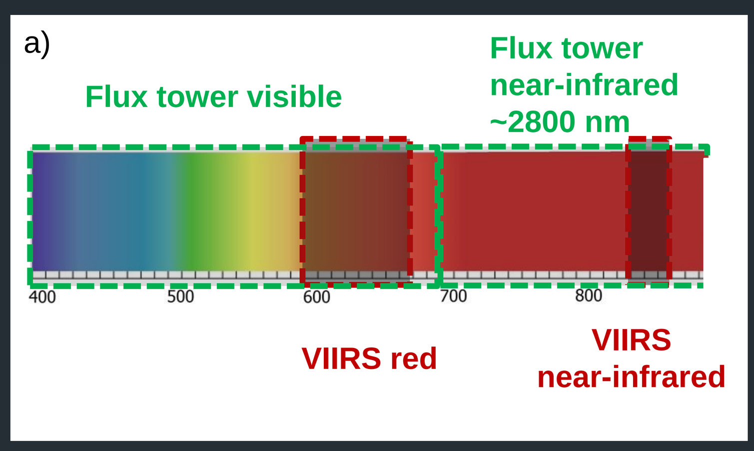
The objective of this study was to validate VIIRS VIs (i.e. TOA NDVI and TOC EVI) by evaluating how well VIIRS VIs capture the seasonal dynamics of vegetated surfaces in comparison with those depicted by in situ VI time series measurements from flux towers:

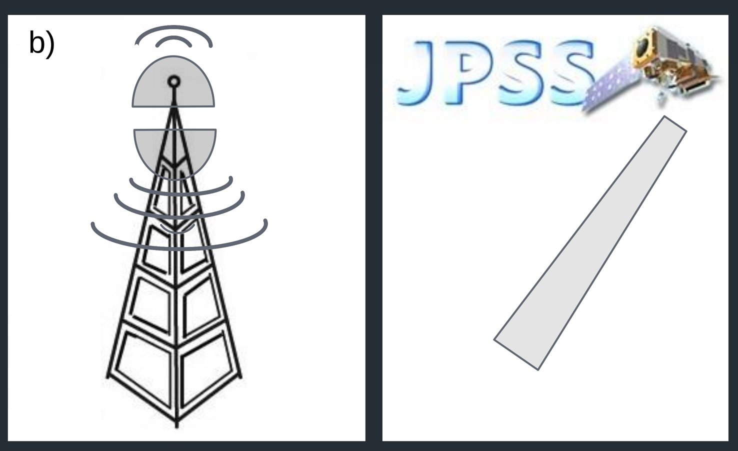
1. Visually compare the **seasonal changes** of VIIRS VIs with those from flux tower VIs. depict the seasonal dynamics
2. Examine **correlations** between VIIRS and flux tower VIs
3. Compare **phenological metrics (i.e. SOS: Start of Season and EOS: End of Season)** derived from VIIRS and flux tower VIs

Data Compatibility Issues

1. Spectral bandpass:
Flux tower broad bandwidth vs. VIIRS narrow bandwidth

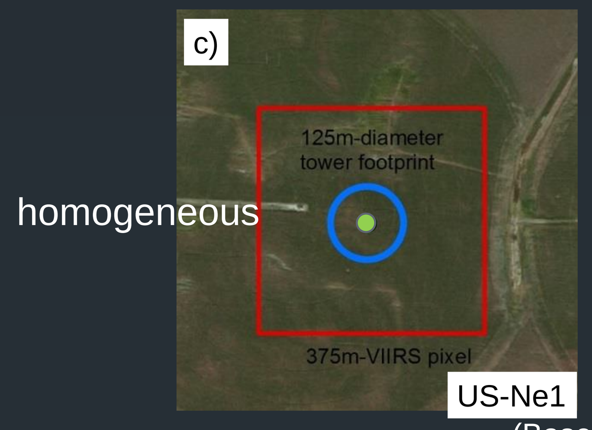
2. Geometry:
Flux tower hemispherical vs. VIIRS directional

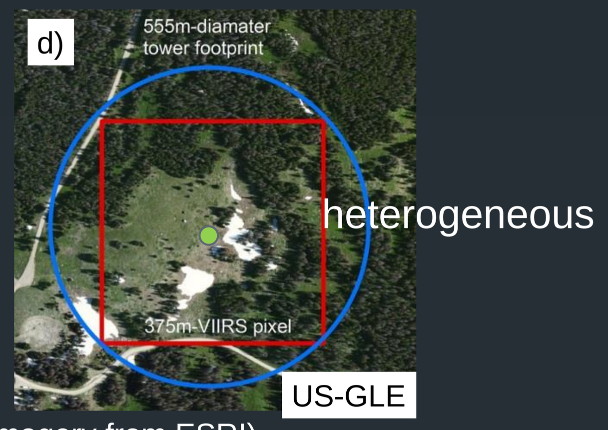




3. Footprint size:
Flux tower---varies at each site with radius from 23 m to 293 m, determined by the tower's height
VIIRS—375 meters at nadir

4. Land surface:
homogeneous vs. heterogeneous





(Base map: World Imagery from ESRI)

Figure 1. Differences in Spectral bandpass, geometry, footprint and land surface.

Methods

1. NDVI and EVI / EVI2

VIIRS

$$NDVI=\frac{R_{nir}-R_{red}}{R_{nir}+R_{red}}$$

$$EVI=2.0*\frac{R_{nir}-R_{red}}{R_{nir}+6*R_{red}-7.5*R_{blue}+1} \qquad EVI2=2.5*\frac{R_{nir}-R_{red}}{R_{nir}+2.4*R_{red}+1}$$

Flux tower[1]

$$NDVI=\frac{R_{nir}-R_{vis}}{R_{nir}+R_{vis}}$$

$$EVI2=2.5*\frac{R_{nir}-R_{vis}}{R_{nir}+2.4*R_{vis}+1}$$

2. VIIRS Data pre-processing (Quality Flags: ice, snow, shadow and cloud)
3. Data post-processing (95% confidence interval for noise removal and moving average for filling missing data)
4. Phenological Metrcis-SOS and EOS

$$NDVI_{ratio}=\frac{NDVI-NDVI_{min}}{NDVI_{max}-NDVI_{min}}$$

The threshold of 50% of NDVI ratio was used in this study. The increase in greenness is believed to be the most rapid at this threshold[2].

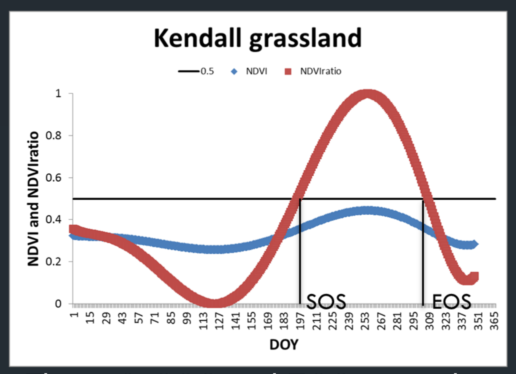


Figure 2. SOS and EOS extraction

Study Sites

Flux towers: **10**	Vegetation cover types: **5**	Data period: daily from April to December 2012

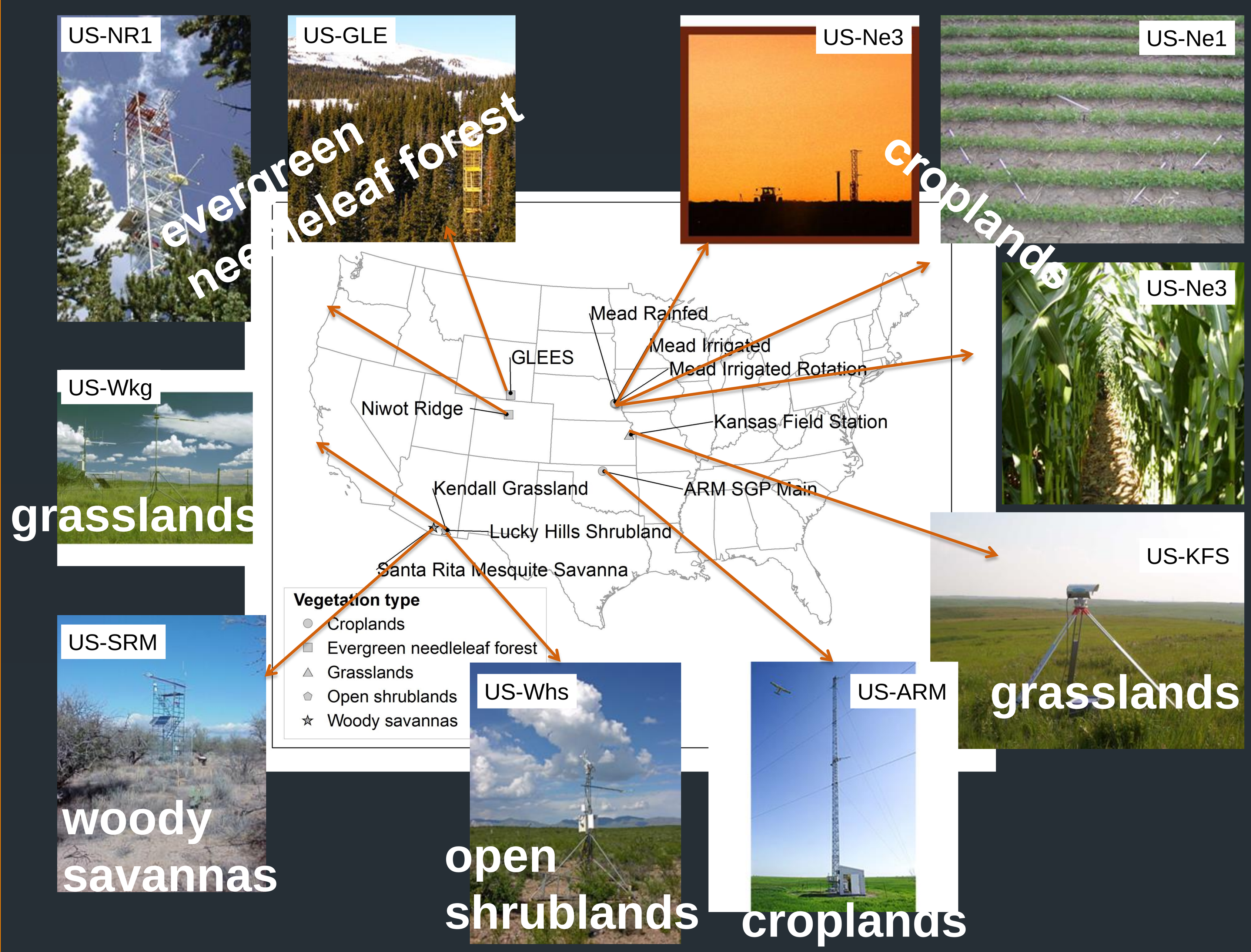


Figure 3. Locations of study sites (Photo credits: Ameriflux website).

Results

1. About 1/3 of VIIRS data were left after running with quality flags and noise removal.
2. Both flux towers and VIIRS present similar seasonal trends for each site and vegetation cover. At croplands and grasslands, VIs showed a unimodal pattern. At homogeneous evergreen needle forest, VIs were relatively constant. At woody savanna and open shrublands, VIs showed multimodel patterns (Figure 4).
3. Scatterplots between VIIRS VIs and flux tower derived VIs showed that these two datasets scattered near the 1:1 line at most sites, except for US-NR1 which is at evergreen needle forest area (Figure 5).
4. Out of 10 sites, 4 were used to extract SOS and EOS, including 3 at croplands and 1 at grasslands. At these 4 sites, both VIIRS and flux tower captured the SOS and EOS during the temporal range from April to December. The differences between SOS were from1 to 10 days, and between EOS were from 0 to 5 days (Table 1 and Figure 6). Sites with SOS earlier than April or no distinct SOS or multi-model growing season were excluded for this study.

1. Seasonal dynamics

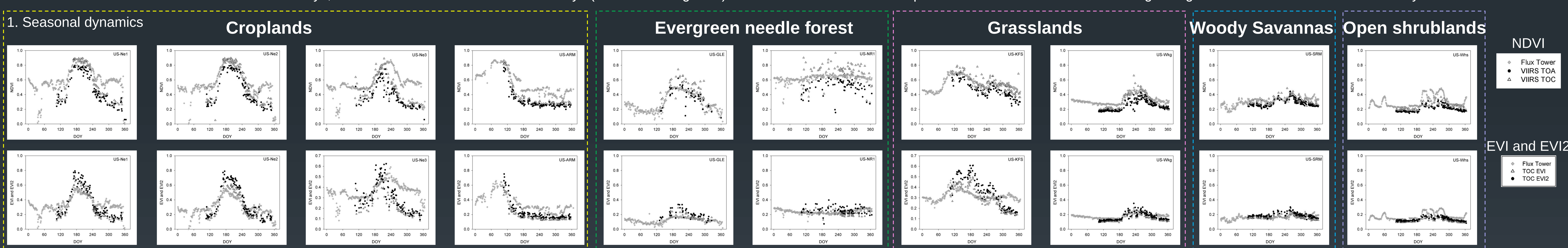


Figure 4. Seasonal plots of NDVI and EVI (EVI2) of VIs from VIITS and flux towers.

2. Correlations

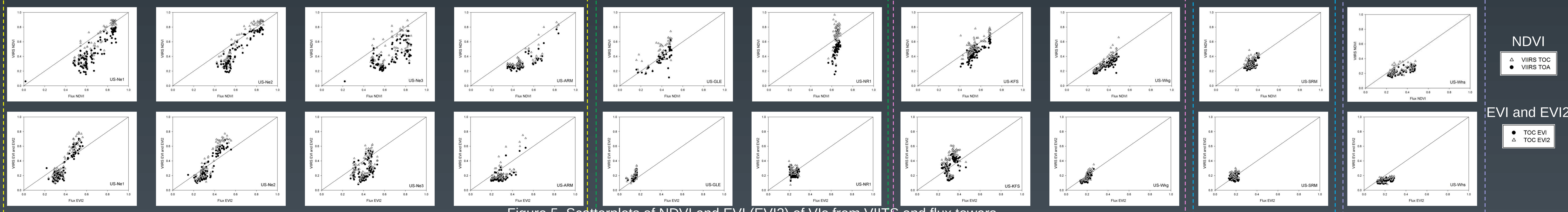


Figure 5. Scatterplots of NDVI and EVI (EVI2) of VIs from VIITS and flux towers.

3. Phenological metrics (showing data for NDVI only, EVI(EVI2) are not shown)

Table 1. SOS and EOS dates for NDVI from VIIRS and flux towers.

SOS (DOY)	TOCNDVI	TOANDVI	FluxNDVI
US-Wkg	196	205	195
US-Ne1	151	151	149
US-Ne2	153	152	148
US-Ne3	160	161	168
Minimum Difference	1	2	
Maximum Difference	8	10	
Mean Difference	0	2.25	
Standard Deviations	5.60	7.04	

EOS (DOY)	TOCNDVI	TOANDVI	FluxNDVI
US-Wkg	304	304	304
US-Ne1	244	242	246
US-Ne2	246	244	241
US-Ne3	254	255	254
Minimum Difference	0	0	
Maximum Difference	5	4	
Mean Difference	0.75	0	
Standard Deviations	3.61	3.51	

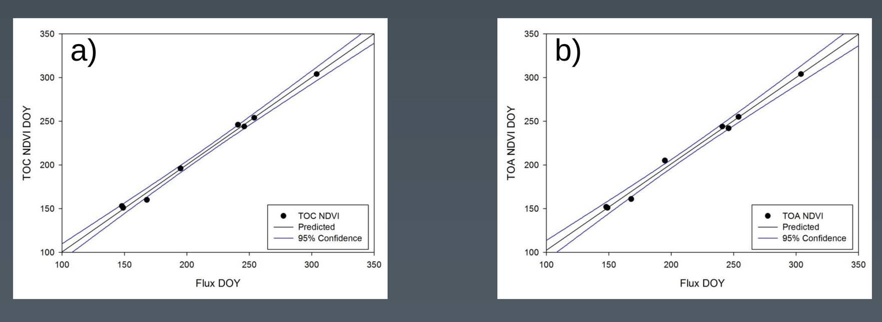


Figure 6. 95% confidence interval for SOS and EOS extracted from NDVI.

Conclusions

1. FLUXNET measurements can be used to validate VIIRS VIs.
2. Daily VIs from flux towers and VIIRS were comparable and both captured similar seasonal dynamics of vegetation.
3. Phenological metrics (i.e. SOS and EOS) extracted from flux towers and VIIRS were within 10-day differences.
4. The methodology presented can serve as a basis for validating medium resolution satellite products.

References

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