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.

Data Compatibility Issues

1. Spectral bandwidth: 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 230 m, determined by the tower’s height VIIRS—35 meters at nadir
4. Land surface: homogeneous vs. heterogeneous

Methods

1. NDVI and EVI / EVI2

- VIs

<table>
<thead>
<tr>
<th>Flux tower</th>
<th>EVI</th>
<th>EVI2</th>
</tr>
</thead>
<tbody>
<tr>
<td>US-NR1</td>
<td>0.42</td>
<td>0.73</td>
</tr>
<tr>
<td>US-GLI</td>
<td>0.40</td>
<td>0.70</td>
</tr>
<tr>
<td>US-Ne3</td>
<td>0.40</td>
<td>0.69</td>
</tr>
<tr>
<td>US-Ne1</td>
<td>0.40</td>
<td>0.69</td>
</tr>
<tr>
<td>US-Ge</td>
<td>0.40</td>
<td>0.69</td>
</tr>
</tbody>
</table>

- The thresholds of NIVI ndvi was used in this figure. The threshold of one to be the most rapid at this threshold.

2. VIIRS Data pre-processing (Quality Flags: ice, snow, shadow and cloud)

3. Data post-processing (VI calculation confidence intervals for noise removal and moving average for filling missing data)

4. Phreatohetic Metrics (SOS and EOS)

![Figure 2: SOS and EOS extraction](image)

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)](image)

Croplands

- Evergreen needle forest
- Grasslands
- Woody savannas
- Open shrublands
- Croplands

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

<table>
<thead>
<tr>
<th>Site</th>
<th>SOS (DOY)</th>
<th>EOS (DOY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US-NR1</td>
<td>153</td>
<td>284</td>
</tr>
<tr>
<td>US-GLI</td>
<td>153</td>
<td>284</td>
</tr>
<tr>
<td>US-Ne3</td>
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<td>US-Ne1</td>
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<td>US-Ge</td>
<td>153</td>
<td>284</td>
</tr>
</tbody>
</table>

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

![Figure 5. Scatterplots of NDVI and EVI (EVI2) of VIs from VIIRS and flux towers.](image)

![Figure 4. Seasonal plots of NDVI and EVI (EVI2) of VIs from VIIRS and flux towers.](image)

![Figure 6. 95% confidence interval for SOS and EOS extracted from NDVI.](image)

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 savannas, VIs were equal in each site.
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 1 at croplands and 3 at savannas. For 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 from 1 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.

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 basic for validating medium resolution satellite products.

References


Acknowledgements

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