

A New Hybrid Method for Remote Sensing VI Time Series Reconstruction

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Introduction

Vegetation indices (VI) are useful proxies for studying vegetation states and dynamics. Three decades of daily global satellite images are currently available, however, the presence of clouds, aerosols, variable viewing geometry and insufficient processing algorithms prevented most of this data from being useful to the scientific community. In an effort to improve the temporal frequency and coverage of high-quality various gap filling techniques were proposed. Most of these methods are based on the use of smoothing techniques, Fourier Transform Functions, Gaussian models, or pixel-wise gap-filling techniques. Here, we are proposing a new technique that aims at producing consistently high quality VI signals, while preserving adequate temporal resolution to support large scale earth surface vegetation change research. The method is based on finding the seasonally variable per-pixel optimal composite period and then applying a simple interpolation technique to address the remaining gaps. The method is constrained by a movable window term average to address biases that may result from data/algorithm.

Optimal Compositing Period

- Figure 2: We composed the NDVI using periods ranging from 2 to 50 days with one day increment. Within 5 to 7 days a reasonably full global coverage is achieved. Any additional days tend to contribute very little, because clouds and other problems persist over particular areas for a very long periods of time (cloudy season for example in the tropics). Even over 50 days there was still spatial gaps.

- Figure 3: Optimum compositing period length corresponds to the intersection between the % cloud free data curve and the Fuzzy score function (FQ).

- Figure 4: Impact of compositing period length on growing season characterization. Longer compositing period tend to drift the phenology curve and consequently changes the start, end and other growing season parameters.

- Figure 5: Seasonal mean of the number of days between useful observations based on the analysis of Terra-MODIS 15-day record of daily observations. This indicates that even very long composite periods are unable to address gaps over certain areas.

Optimal compositing period is determined by maximizing the intersection of the curves representing the percentage of available cloud-free data (black squares) and the Fuzzy score function (FQ). For a typical seasonal phenology curve, the window and its metric are defined to represent the growing season. The longer (shorter) phenology curve, the shorter (longer) compositing period required. The optimum compositing period was determined by selecting the maximum of the intersection between the curves.

Inverse Distance Weighting Method

Once the data is properly composed to retain the highest quality data, the resulting gaps are filled using the Inverse Distance Weighting (IDW) method. This method estimates the missing data by using a moving window. This method is based on the assumption that the intensity of a spectral band at a location must be the sum of the neighboring bands less the noise and the distance between the bands.

Conclusions

Our analysis show that the global composite period length should be close to 5-7 days. This implies a balance between the need for a short composite period to detect small change and high quality data. The remaining gaps are then filled using the IDW method. This new hybrid method has several advantages:

1) It is simple and less computer intensive.
2) It is superior to other methods since it only looked at the data around the temporal gap which helps eliminate the biases that may result from methods that simultaneously need the full annual cycle.
3) It keep a balance between preserving higher frequency and higher quality data without the noise associated with daily data while avoiding the excessive smoothing of other methods.

This new method did however show sensitivity to residual noise in the composited data. More advanced filtering techniques are needed to alleviate this issue.

This method is currently being implemented as a package to support the estimation of global phenology and to generate high quality long term Earth System Data Records of Vegetation Index from multiple sensors.

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References


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