MODIS VI Product Reliability Index: Improving The Quality Of Time Series Data

Kamel Didan[1], Alfredo Huete[1]

[1] Terrestrial Biophysics & Remote Sensing Lab., Department of Soil, Water, and Environmental Science, The University of Arizona, Tucson, AZ 85721, USA
kamel@ag.arizona.edu

Abstract and Introduction

The MODIS (Terra and Aqua) biophysical products are designed to provide key, long-term time series measurements that have their heritage in the NOAA-AVHRR data record and which serve as a bridge to the future NPOESS platform.

All MODIS land products generate per-pixel quality information intended for incorporation into end users post processing. Quality information can assist in separating true change from noise and low quality induced data artifacts.

Users' feedback, however, suggests that the complexity of the current quality information stored in the MODIS products is very challenging. The need for a new quality metric was assessed in light of the 5 year MODIS data record. A simpler more accessible data reliability metric was developed in this study. This new reliability 'index' was evaluated and its usefulness established. It was found to be :

- Very robust and correlated well with data quality (captured all data problems),
- Simple (only a few categories), and
- Very useful for a multitude of post-processing scenarios

Although this work is based on the analysis of the MODIS VI time series, other MODIS land products can adapt similar indices, provided they capture the product specific quality attributes. We expect such changes to positively impact the MODIS data record, the user community, and future missions as they draw from the MODIS experience.

Objectives

An ideal quality assignment system for remote sensing data is one that enables end users to extract actual change in the target characteristics that are not due to noise and irrelevant influences, such as clouds and aerosols.

In this context, an ideal reliability index should have the following characteristics:

- Simplicity: Following a ' Use/Don't use', 'reliable/Not reliable' logic
- Limited in scope: With as few categories as possible
- Take into account the variety and potential uses (some models/applications might tolerate uncertainty/fuzziness more than others)
- Require none or limited post processing (another facet of the simplicity issue)

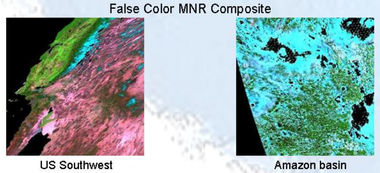
Methodology

Limiting the scope of this study to the MODIS Terra platform, we devised a QA analysis scheme that will answer the following two questions:

- Which of the quality fields, currently produced by MODIS, are the most influential factors on quality?
- In what order do they affect the data quality?

Two 1km tiles, h08v05 (US southwest) and h12v09 (Amazon basin) were chosen for this analysis. Cloud and snow are present in these areas, along with homogeneous and mixed land cover conditions. We then looked at the relationship between the quality metric and the data spatial and temporal behavior.

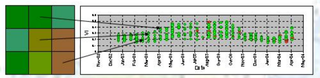
False Color MNR Composite



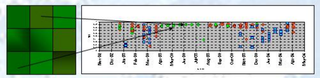
US Southwest
Tile h08v05

Amazon basin
Tile h12v09

Using a 3x3 pixels window running across the whole tile, we computed the average VI signal for the window. Only cloud and snow free pixels were used to generate these average profiles. We first assumed that the average profile represents the closest to-'true' temporal signal for all pixels in that window, provided it is homogeneous. Deviations from this 'true' profile are caused by reduced quality and problematic processing. Figure 1 illustrates the concept behind these assumptions.



Heterogeneous case: Example time series for all 9 pixels, 'noise' in the series is due to both heterogeneity and possibly atmosphere contaminants and other quality issues.



Homogenous case: Example time series for all 9 pixels; When there are no atmosphere contaminants, or quality issues, the nine profiles should match. Noise from atmosphere causes each profile to deviate from the average.

Figure 1: Quality Information Spatial Analysis

This analysis shows that, excluding clouds and snow, the most important driving quality metrics in order of importance are aerosol, shadow and viewing geometry. Heavy and medium aerosols will greatly reduce the data quality, shadow plays a similar role. Low to no aerosol loads should fairly be addressed by the atmosphere correction algorithm. This information was then used in designing the new reliability index.

New Reliability Index

The new reliability index was designed following figure 2 (MODIS VI case). This new index takes the following values:

- No data : Out of range or not processed due to various reasons
- Cloudy Data: Mostly kept for spatial completeness only
  - Not useful
- Snow covered data: Canopy or background covered with snow
  - Limited usefulness
- Semi-reliable data: No cloud and no snow, the target is visible and atmosphere correction has improved the data quality.
  - Useful for most applications, except when higher quality data is needed
- Reliable data: No cloud no snow, and light to no aerosol loads. This data is the most ideal, given other limitations.
  - The most ideal, given other limitations, should drive most applications, research, and decisions under the most demanding circumstances
  - Other data can also be compared to this and retained/rejected accordingly

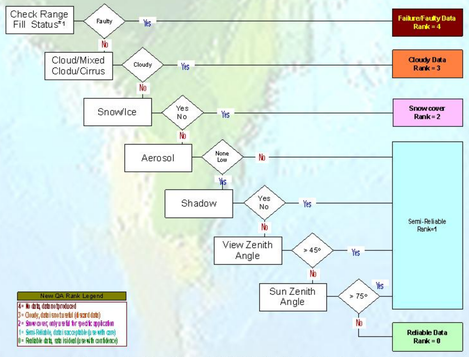


Figure 2: The New MODIS Reliability index.

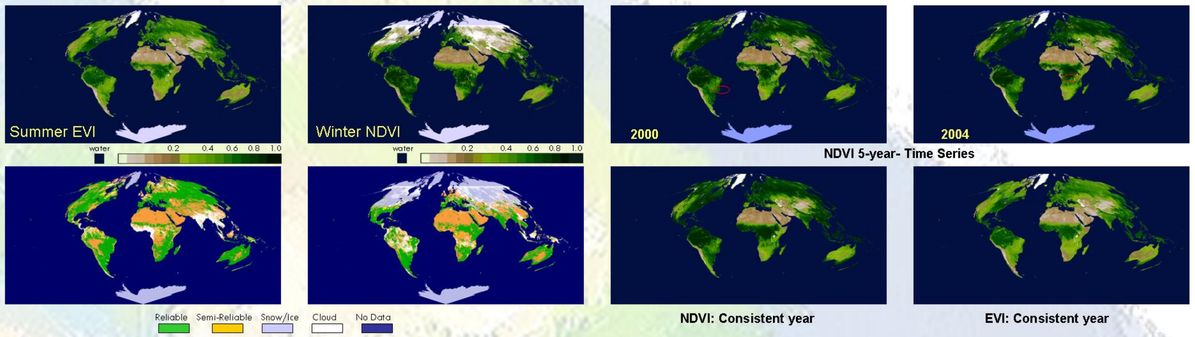
Example Applications of the new reliability index

Three example applications are presented to illustrate how such a reliability index might be used, and its impact on post-processing analysis:

- Reliability index maps
- Time series analysis
  - The reliability index was used to look at time series and aid in the extraction of 'true seasonal profiles'
- Consistent Global annual average profiles
  - The MODIS Terra 5 year-record was processed into one consistent average year for the study of annual change and seasonality.

Reliability index maps

These maps could be used instead of the more complex MODIS quality fields.



Per Pixel Global Reliability Maps

Annual change and seasonality

Using this new reliability index we were able to process the Terra MODIS 5-year data record into an average year time series, that is useful in studying annual change, even under the worst cloud cover conditions.

NDVI 5-year- Time Series

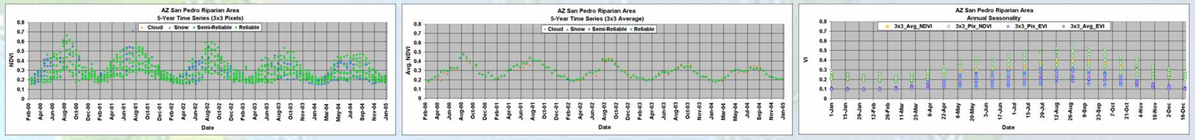
NDVI: Consistent year

EVI: Consistent year

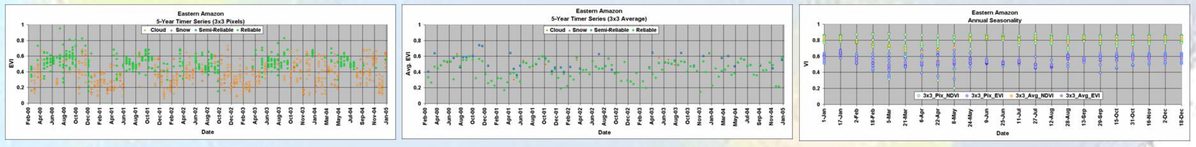
Time Series Analysis and Change Detection and Monitoring

Using this new reliability index we were able to extract the seasonal signatures under extreme cloud cover patterns.

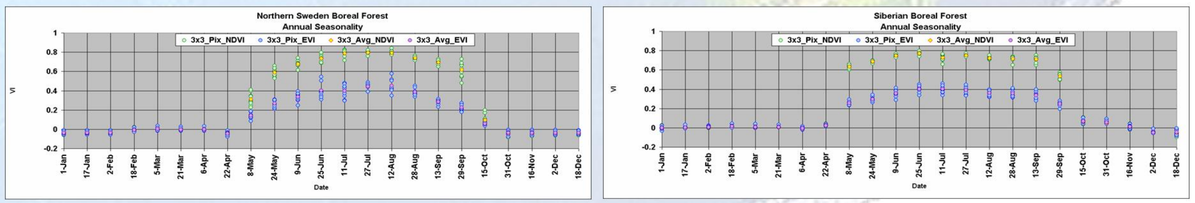
Example drought impact: US southwest, San Pedro river



Phenology extraction under perpetual cloud cover



Short growing season and Boreal forest seasonal profiles



Conclusions

In this study, we identified some issues associated with the current MODIS quality information as it impacts post analysis, we were able to design a new data reliability index. This index was evaluated and its potentials assessed on various post-processing scenarios. This new reliability index captured all the data problems, was very simple, and quite useful for a variety of applications.

Acknowledgements: This work was supported by NASA MODIS contract # NNG04HZ20C