SYNOPTIC GLOBAL REMOTE SENSING OF LAND SURFACE VEGETATION: OVERVIEW OF DAILY DATA QUALITY, CHALLENGES, AND OPPORTUNITIES

Armando Barreto[1*], Kamel Didan[1,2], Muluneh Yitayew[3]

[1] VIP Lab., ECE Dept, [2] Institute of the Environment, [3] ABE Dept. The University of Arizona, Tucson, AZ 85721, USA
*abarreto@email.arizona.edu

Introduction

Continuous collection of global satellite imagery over the years has contributed to the creation of a long data record from AVHRR, MODIS, SPOT-VGT, and other sensors. Currently, these records span more than three decades of earth observing, and are critical to understanding Earth System processes, to assessing change and long term trends, provide input and validation means to modeling efforts, and support policy decisions and operational services.

Whereas, for most atmospheric research these records are ideal as is, for studies dealing with Earth surface processes they are extremely challenging to work with. The presence of clouds, aerosols, spatial gaps, variable viewing conditions, less than consistent atmosphere correction, and other data processing issues, makes it difficult to obtain the necessary high quality data everywhere and every time. Furthermore, these issues change by location and time, making it ever more difficult to work with these data.

Objectives

One of the stated goals of NASA Making Earth Science Data Records for Use in Research Environments (MEaSUREs) program is the support of the Earth Science research community by providing reliable Earth Science Data Records (ESDR). These products are expected not only to be of high quality but should also combine data from multiple sources to form the long and coherent measurements required for studying climate change impact on the Earth system.

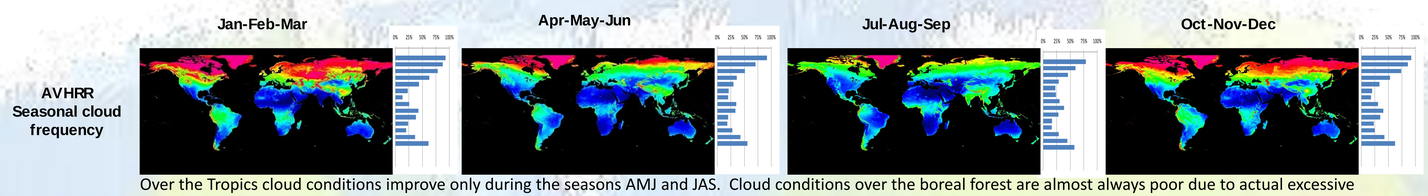
To address the first goal of providing reliable data, it is imperative to accurately understand and quantify the extent of the data quality, both in time and in space. Accurate characterization of the data quality is a prerequisite to combining the multi-sensor records. With that in mind, the objectives of this research, were:

- To assess the global AVHRR and MODIS daily records data quality
- To create spatial and temporal data quality probability maps
- To analyze this information in order to enable the accurate data fusion across multiple sensors

Data and Methodology

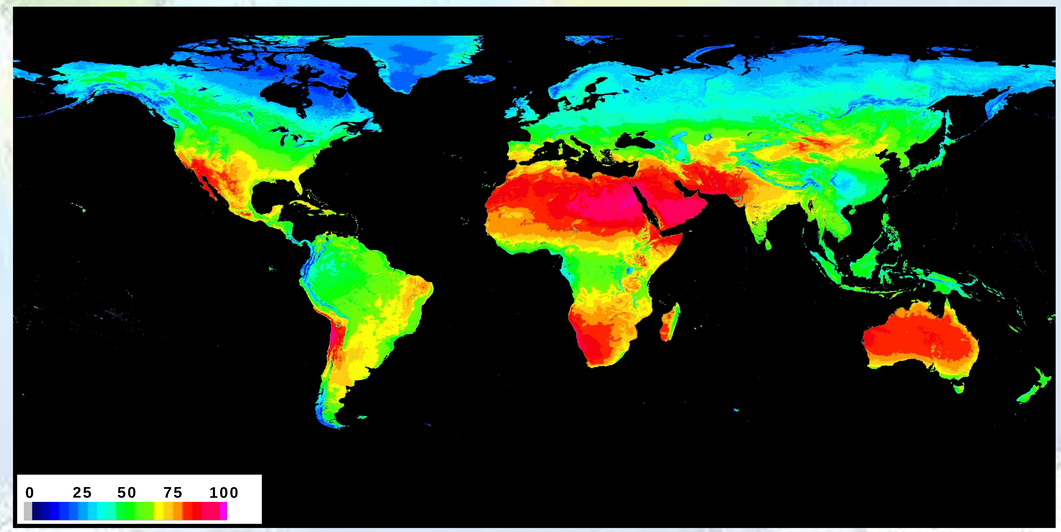
We used the daily global 0.05º resolution Advanced Very High Resolution Radiometer (AVHRR) surface reflectance from 1981 to 1999 and the daily Terra (starting March 2000) MODerate Resolution Imaging Spectroradiometer (MODIS) surface. Both records provide daily data surface reflectance and quality information about clouds, partial clouds, shadow, presence of ice and snow, additionally MODIS provides information about aerosols.

We extracted and analyzed this per pixel quality information, and further stratified this analysis per season, land cover type, and geographic location. A measure of data reliability modeled after the MODIS Vegetation Index Collection 5 Algorithm (Didan & Huete, 2002) was generated for both data records. This data reliability measure is useful in guiding the data continuity objectives of this overall project. In doing so we also identified opportunities for further work on these data records.



Over the Tropics cloud conditions improve only during the seasons AMJ and JAS. Cloud conditions over the boreal forest are almost always poor due to actual excessive cloudiness and the poor performance of the AVHRR cloud algorithm. This translates to an overall inadequate data reliability with AVHRR over those biomes.

For MODIS, data is consistently cloudiest over the Tropics, and the cloud algorithm does a better job over the boreal forest. This again, translates to similar data reliability challenges as with AVHRR but less so over the boreal forest.

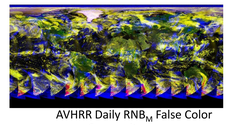


30-year combined AVHRR and MODIS average yearly good data yield. This map reveals the 'probability' of finding useful synoptic land surface remote sensing data for any particular location on Earth for the last 30 years of Earth observing.

The AVHRR data record (~20 yrs), as opposed to the MODIS shorter records (~10), overwhelmed the reliability of the record. Most vegetated biomes suffer from lack of good data , in particular the high latitudes and the tropics.

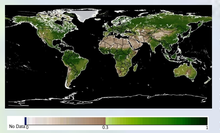
This data reliability map will guide our multi-sensor continuity work as it will both indicate the level of expected accuracy and identify the data to eliminate from these records.

MODIS Daily RNB False Color Composite Image



AVHRR Daily RNB_M False Color Composite Image

Daily global surface reflectance illustrating the challenges of working with synoptic RS data (clouds and other issues). RNB_M denote MODIS blue band.



Desired global EVI2 map, showing vegetation at its peak. Going from the above problematic daily data to this high fidelity VI map is the task of this MEaSUREs project.

The two major biomes, Rain forest and Boreal forest, represent the bulk of global land surface vegetation yet they are the areas most challenging to work with.

Results and Discussions

This analysis supports these observations:

- The MODIS data quality characterization is more thorough and accurate, in particular with cloud identification. The AVHRR cloud algorithm (CLAVR, Stowe et al., 1999) tends to confuse snow/ice, and/or other bright targets, with clouds leading to excessive omissions and commissions. The opportunity here is that a better cloud and ice/snow screening algorithms are needed to assist with the multi-sensor continuity research.
- The data quality over the Rainforest and Boreal forest, two critical biomes undergoing serious climate driven change, are the poorest, owing to excessive cloud cover, aerosols and ineffective atmosphere corrections. The opportunity here is that longer multi-sensor records and more robust data analysis techniques are needed in order to make effective use of this data over these areas.
- The need for daily data to support accurate Phenology and other land surface processes research may be unattainable, indicating once again the need for robust algorithms and techniques to deal with the resulting spatial and temporal gaps.

Conclusions

These observations suggest that research based on synoptic remote sensing is more challenging than what current literature implies. This is further complicated by the lack of continuity across these various global imagers. On the opportunity side, some ideas may help alleviate these challenges:

- The creation of consistent multi-sensor data records assisted by this quality information, thus the goals of this MEaSUREs' project (started in August 2008)
- Geostationary platforms may become an effective mean to dealing with the cloud problem
- The use of data reliability as a simple first order mean to separate useful data in a record.

References

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vegetation index & phenology Lab. ...Understanding a piece of the Earth system

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