Feasibility of Estimating Relative Nutrient Contributions of Agriculture and Forests Using MODIS Time Series

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Abstract

Around the Gulf of Mexico, high-input crops in several regions make a significant contribution to nutrient loading of small to medium estuaries and to the near-shore Gulf. Some crops cultivated near the coast include sorghum in Texas, rice in Texas and Louisiana, sugarcane in Florida and Louisiana, citrus orchards in Florida, pecan orchards in Mississippi and Alabama, and heavy sod and ornamental production around Mobile and Tampa Bay. In addition to crops, management of timberlands in proximity to the coasts also plays a role in nutrient loading. In the summer of 2008, a feasibility project is planned to explore the use of NASA data to enhance the spatial and temporal resolution of near-coast nutrient source information available to the coastal community. The purpose of this project is to demonstrate the viability of nutrient source information products applicable to small to medium watersheds surrounding the Gulf of Mexico. Conceptually, these products are intended to complement estuarine nutrient monitoring.

Near-Coast Crops

Introduction

This project seeks to use NASA data to enhance the spatial and temporal resolution of near-coast cropping information available to the coastal community. In doing so, we hope to contribute to an improved understanding of nutrient loading and nutrient sources for sensitive water bodies around the Gulf of Mexico.

Remote sensing can be effectively applied to determining the distribution of the crops. LULC (land use/land cover) information is a well-established part of modeling nutrient flux at the watershed level. LULC is often produced through classification of multispectral remote sensing data, but this effort proposes to derive the land cover information for crops through time series analysis of multitemporal datasets of the MODIS (Moderate Resolution Imaging Spectroradiometer) sensor. Additionally, we hope to provide information relevant to intra-annual variations in nutrient flux, such as

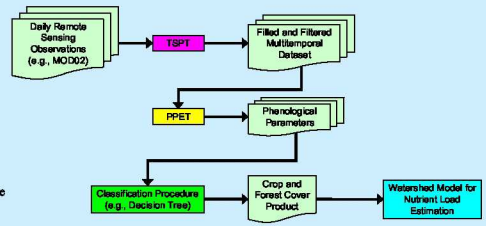
* The presence or absence of canopy to intercept precipitation, and
* The timing of fertilization based on ancillary information regarding the relationship of crop phenology and management practices.

After producing the crop information, we propose to demonstrate its usefulness by showing how the information might be input into one or more nutrient loading models.

Potential Products

- Provide near real-time Land Use/Land Cover information
- Utilize phenology products to infer application dates for fertilizer
- Identify periods when precipitation runoff is most likely using phenology parameters to assess the presence/absence of vegetation canopy

Proposed Flow from NASA Remote Sensing Observations to Watershed Model Input



Typical MODIS Input Datasets

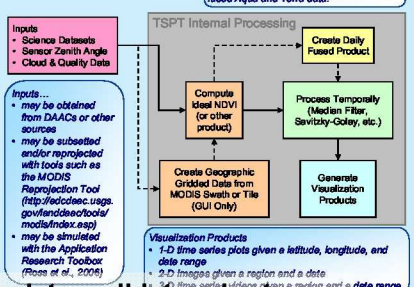
- MOD02 Planetary Reflectance (Swath)
- MOD35 48-bit Cloud Mask
- MOD03 Sensor Zenith Angle
- MOD09 Surface Reflectance (Tile)
- MOD09 Metadata including Cloud Information
- MODMGGAD Sensor Zenith Angle

Time Series Product Tool (TSPT)

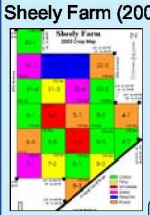
TSPT Overview

The TSPT software was custom-designed for NASA to rapidly create and display single-band and band-combination time series, such as NDVI (Normalized Difference Vegetation Index) images, for wide-area crop surveillance, forest health, disturbance detection, and other time-critical applications. The TSPT, developed in MATLAB®, allows users to create and display various MODIS products as single images, as time series plots at a selected location, or as temporally processed image videos. The TSPT has been used to generate NDVI time series to monitor crop phenology in California and Argentina and to monitor forest health in an area of southeast Mississippi following Hurricane Katrina.

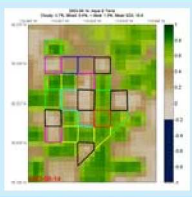
TSPT Data Flow



Sheely Farm (2003)



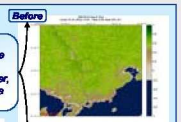
Color-coded Sheely Farm Crop Map



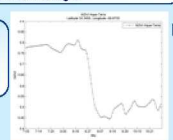
Fused and temporally processed NDVI from MOD02 (Planetary Reflectance), MOD03 (includes θ_s), and MOD35 (Cloud Mask). Planted cotton and pime fields stand out from other Sheely Farm crop fields (9/14/2003).

Katrina (2005)

On right, fused and temporally processed Aqua and Terra NDVI from MOD02, MOD03, and MOD35 before the storm on 8/24/2005 and after the storm on 9/21/2005. The eye passed over Stennis Space Center, outlined in black, adjacent to the Mississippi-Louisiana border. Bay Saint Louis is on right.



NDVI plot at latitude 30.3456 and longitude -89.6736, a few miles southwest of Stennis.



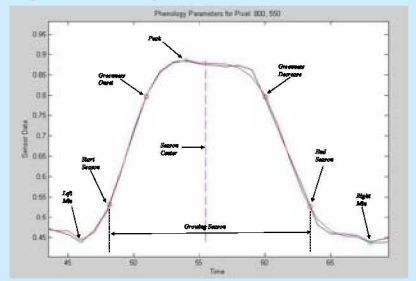
Phenological Parameters Estimation Tool (PPET)

PPET Processing Overview

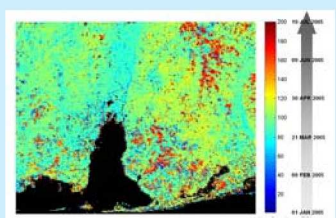
For each data pixel:

1. Extract the TSPT-filtered time series data for each year
2. Identify growing seasons via sinusoidal curve fitting
3. Locate targeted data points within the growing season
4. Calculate the NDVI data value and day of year for each phenological parameter of interest
5. Compute cumulative integrals: 23 integral values accumulated over each 16-day period within the NDVI time series per year
6. Generate BSQ (Band Sequential) generic binary files as output data products

Targeted Phenological Data Points



Example Phenological Parameter: Start-of-Season for Mobile Bay Area for 2005 Season



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