Remote Sensing Time Series Product Tool

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Introduction

The TSPT (Time Series Product Tool) 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 and other time-critical applications. The TSPT, developed in MATLAB, allows users to create and display various MODIS (Moderate Resolution Imaging Spectroradiometer) or simulated VIIRS (Visible/Infrared Imagery Radiometer Suite) products as single images, as time series plots at a selected location, or as temporally processed image videos.

MODIS is ideal for monitoring large crop areas because of its high temporal revisit rate (twice daily), its near global coverage, and its relatively small ground sample distance (250 m). Because MODIS imagery is acquired daily, rapid changes in vegetative health can potentially be detected. With the TSPT, noise removal and temporal processing techniques allow users to create low-noise, daily time series plots and image videos. MODIS metadata is used to find and optionally to remove bad, cloudy, and suspect data. The TSPT features the important capability of fusing data from the MODIS instruments onboard the Aqua and Terra satellites, which nearly doubles the effective temporal resolution.

The TSPT GUI (graphical user interface) provides an interactive environment for crafting “what-if” scenarios by enabling a user to repeat product generation using different settings and thresholds. The TSPT Application Programming Interface provides more fine-tuned control of product generation, allowing experienced programmers to bypass the GUI to create more user-specific output products, such as comparison time plots or images.

This type of time series analysis tool for remotely sensed imagery could be the basis of a large-area vegetation surveillance system. 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.

Ideal NDVI

- Calculate NDVI from red and NIR (near-infrared) reflectances (input can be planetary reflectance or surface reflectance).
- Eliminate pixels acquired at high sensor zenith angle (θz).
- Eliminate bad, clouded, or otherwise suspect pixels.

Fused Aqua and Terra

For each pixel, use the NDVI, cloud data, and other metadata to choose between Aqua and Terra
- PER PIXEL: If Aqua is chosen, use Terra NDVI, θz, and cloud data
- PER PIXEL: If Terra is chosen, use Terra NDVI, θz, and cloud data

Temporally Processed NDVI

- Input can be from Aqua, Terra, or Fused Aqua & Terra NDVI. Similarly, for simulated VIIRS, the input could be VIIRS 1010, VIIRS 1310, or Fused 1030 and 1330 VIIRS.
- Processing is performed in time dimension only.
- Although handled internally as 3-D arrays, the processed output is 2-D raster grids (one for each day).

Sheely Farm (2003)

Color-coded Sheely Farm Crop Map

Fused and temporally processed NDVI from MOD02 (Planetary Reflectance), MOD03 (includes θz, and MOD05 Cloud Mask). Planted cotton and jima fields stand out from other Sheely Farm crop fields (8-14-2003).

Summary

- The TSPT provides a wide range of multitemporal analysis and visualization tools for detecting rapid changes in vegetation vigor via remote sensing imagery.
- The TSPT makes judicious use of available metadata to locate and optionally to eliminate bad, cloudy, or otherwise suspect pixels.
- The TSPT enables fusion of cross-calibrated sensors.

Future Development

- To support rapid prototyping efforts, integration with the Application Research Toolbox, used to simulate future data sources (Ross et al., 2006), is underway.
- To provide easier integration with other tools, portions of the TSPT are being extracted as separate, stand-alone modules able to input and output common data file formats, such as GeoTIFF, ENVI@ BSQ (band sequential), and HDF (Hierarchical Data Format).

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TSPT Data Flow

Inputs:
- Science Datasets
- Sensor Zenith Angle
- Cloud & Quality Data

Multiple, temporally processed images can be created from angle sensors or from fused Aqua and Terra data.

Get and process input data.

Create Daily Fused Product

Include: NDVI, MET data, Land Use, etc.

Fused Daily NDVI vs. MOD13 16-Day NDVI

On right, fused and temporally processed Aqua and Terra NDVI from MOD02, MOD03, and MOD08 before the storm on 8-24-2005 and after the storm on 8-27-2005. The eye passed over Stennis Space Center, outlined in black, adjacent to the Mississippi-Louisiana border. Bay St. Louis is on right.

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