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 Imager/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). The TSPT Application Programming Interface provides more fine-tuned control of MODIS imagery acquisition (other than the MOD09 Cloud Mask) and allows 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.

TSPT Data Flow

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

Inputs may be obtained from DAACs or other sources and may be substituted or reprocessed with tools such as the MODIS Reprojection Tool (http://edcdaac.usgs.gov/tools/modis/index.asp) or may be simulated with Application Research Toolbox (Ross et al., 2006).

TSPT Internal Processing

• Create Daily Fused Product

Visualization Products:
• NDVI Maps and Plots
• NDVI Time Series Plots (one for each day)

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 (θs).
• Eliminate bad, clouded, or otherwise suspect pixels.

Fused Aqua and Terra
For each pixel, use Terra NDVI, θs, and cloud data
• PER PIXEL: If Aqua is chosen, use Terra NDVI, θs, and cloud data
• PER PIXEL: If Terra is chosen, use Terra NDVI, θs, and cloud data

Temporal Processed NDVI
Input can be from Aqua, Terra, or Fused Aqua & Terra NDVI. Similarly, for simulated VIIRS, the input could be VIIRS 16 days, VIIRS 13 days, or Fused 16/13 and 13/13 VIIRS.
Processing is performed in time dimension only.
Although handled internally as 3-D arrays, the processed outputs are 2-D raster pixels (one for each day).

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).

Sheeley Farm (2003)
Color-coded Sheeley Farm Crop Map
Fused and temporally processed NDVI from MOD02 (Planetary Reflectance), MOD03 (Cloud Mask). Cotton and pima fields stand out from other Sheeley Farm crop fields (8-14-2003).

Katrina (2005)

On right, fused and temporally processed Aqua and Terra NDVI from MOD02, MOD03, and MOD09 before the storm on 8-24-2005 and after the storm on 9-27-2005. The eyes passed over Stennis Space Center, outlined in black, adjacent to the Mississippi-Louisiana border. Bay Saint Louis is on right.

MOD09 and MOD03 GAC, with MOD13 16-day Aqua and Terra NDVIs shown for comparison.

Note that the daily NDVI shows a drop off more than 15 days before MOD13. This difference would be critical in early detection of sudden threats to crop health.

Ideal NDVI Time Series
• Median Filter
• Interpolate Seasonality/Geoid filter

Fused Daily NDVI vs. MOD13 16-Day NDVI

Related Poster & Presentation
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