Northern Rocky Mountain Science Center
U.S. Department of the Interior
Geological Survey

Development and Evaluation of Synthetic High Resolution Satellite Imagery for Effectiveness Monitoring

In the semi-arid shrub-steppe regions of southwest Wyoming, researchers with the US Geological Survey's Northern Rocky Mountain Science Center are testing the effectiveness of a remote sensing process that could facilitate monitoring changes in plant phenology and biomass at a spatial and temporal resolution not previously possible. This novel approach could help inform management decisions related to vegetation dynamics as well as resource distribution and wildlife space use. The current study area includes regions managed by the Bureau of Land Management's Kemmerer Field Office, Fossil Butte National Monument, the Bridger-Teton National Forest, and the Cokeville National Wildlife Refuge.

Background

Land managers require objective detailed information about dynamic vegetation characteristics when evaluating habitat conditions and trends. While vegetation indices such as the normalized difference vegetation index (NDVI) can be used to monitor seasonal and interannual changes in plant phenology and biomass, assessing the efficacy and duration of management activities has been problematic due to a lack of high resolution spatial and temporal data capable of revealing patterns of vegetation response and changes in forage production. New data fusion methods that blend high frequency temporal data provided by Moderate Resolution Imaging Spectroradiometer (MODIS) sensors and high spatial resolution data available via the Landsat platforms can provide the fine resolution spatiotemporal data required to evaluate habitat responses to management activities across broad landscapes. This method has been successfully applied to landscapes such as forested areas, cropland, and a mixture of forest and cropland, but remains untested in semi-arid shrub-steppe dominated areas, such as southwest Wyoming. Research led by the USGS is investigating the ability to measure vegetation characteristics across large spatial extents at fine temporal and spatial scales in this region.

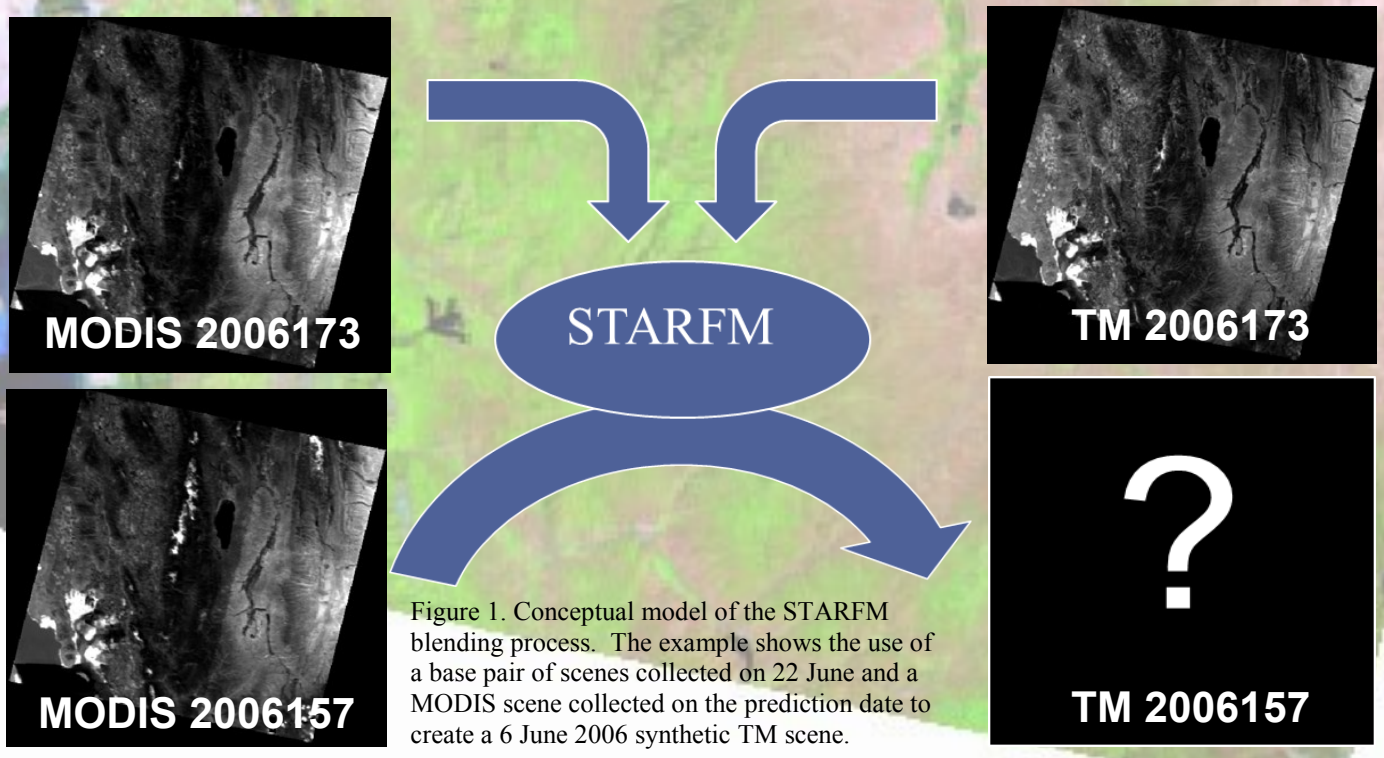

Figure 1. Conceptual model of the STARFM blending process. The example shows the use of a base pair of scenes collected on 22 June and a MODIS scene collected on the prediction date to create a 6 June 2006 synthetic TM scene.

Data Blending and Evaluation of Synthetic Vegetation Indices

Twenty scenarios with varied input and prediction dates were evaluated to determine the accuracy of predicted spectral data and vegetation indices. Researchers used publically accessible satellite imagery consisting of cloud-free Landsat Thematic Mapper (TM) and Terra MODIS scenes collected from May through October 2006. The Spatial Temporal Adaptive Reflectance Fusion Model (STARFM) algorithm was used to generate synthetic (predicted) TM reflectance values based on differences between paired TM and MODIS scenes collected on the same day and a MODIS scene collected on the prediction date (Figure 1). Synthetic NDVI estimates were calculated using the reflectance values of each predicted TM scene and stratified by land cover/land use. The spectral quality of each set of estimates was assessed on a per-pixel basis based on the difference between actual and predicted values. Pixel-based regression analysis was used to determine the relationship between observed and predicted values. Reflectance and NDVI values were successfully predicted across the study area. Estimates correlated well with measured values and were reasonably accurate and unbiased when prediction dates were near the date of the paired Landsat-MODIS image set. The strength of these relationships decreased as lag between the date of the paired image set and the prediction data increased. The performance of the data fusion process also varied among land cover types. NDVI estimates associated with sagebrush shrubland and steppe cover types were highly correlated with known values (Figure. 2) while those associated with cropland and pasture/hay exhibited a weaker relationship.

Image courtesy of the National Park Service.

Application

The synthetic imagery produced by data blending provides the high spatial resolution managers need to identify treatment areas, the high temporal resolution often needed to track dynamic vegetation conditions, and the large spatial extent needed for monitoring at landscape scales. Synthetic reflectance and NDVI data should be useful to area land managers seeking to monitor intra- and interannual changes associated with vegetation treatments or changing climatic conditions. Similar data are currently being developed for use in modeling elk distribution in response to land management practices (See http://nrmsc.usgs.gov/files/norock/products/Olexa_090210_FINAL.pdf), and could be applied to sagebrush obligate species (e.g., sage-grouse and pygmy rabbit).

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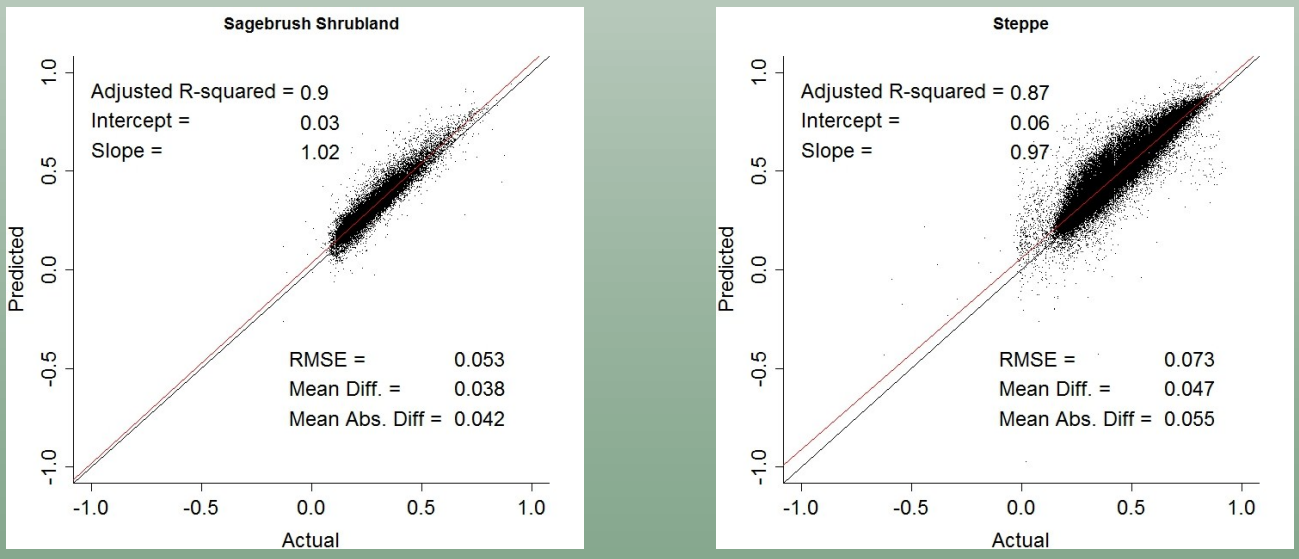

Figure 2. Per-pixel comparison of observed NDVI values versus those predicted for 6 June 2006 using a Landsat-MODIS image pair collected on 22 June 2006. Accuracy and bias estimates from the associated difference image are also presented.

The Northern Rocky Mountain Science Center is located in Bozeman, Montana and includes three field stations in Montana and one duty station in Wyoming. For more information on NOROCK's research, please visit http://nrmsc.usgs.gov or contact the Center Director: Jeff Kershner 406-994-5304 or jkershner@usgs.gov