An Empirical Investigation of Reflectance and Vegetation Index Continuity/Compatibility Using EO-1 Hyperspectral Hyperion

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Numerous satellite sensor systems have recently been launched and satellite derived products from these multiple sensors are increasingly being used in regional to global vegetation monitoring. In order to make the best use of data products from different sensors, data product continuity and compatibility need to be investigated. Compatibility problems among the data products exist due to differences in sensor characteristics and algorithms used to process the data. This investigation focused on the spectral characteristics of multiple sensors and their influences on the derived vegetation index (VI) values. VI continuity was considered to be attained when the VI values computed from the reflectance data produced by the different sensors become the same for the same target under identical conditions.

The study sites were located along an eco-climatic gradient in Brazil, including, from north to south, the Tapajos National Forest, Araguaia National Park, Brasilia National Park, and their surrounding areas (Figure 1). Hyperspectral Hyperion images over these sites were acquired in the 2001 dry season (July). The images were spectrally convolved and processed to simulate atmospherically-corrected surface reflectance and normalized difference vegetation index (NDVI) values for the Terra's Moderate Resolution Imaging Spectroradiometer (MODIS), the Landsat Enhanced Thematic Mapper Plus (ETM+), and NOAA-14's Advanced Very High Resolution Radiometer (AVHRR) band passes. Inter-sensor continuity/compatibility of the reflectance and NDVI were investigated through correlative comparisons of one sensor to another.

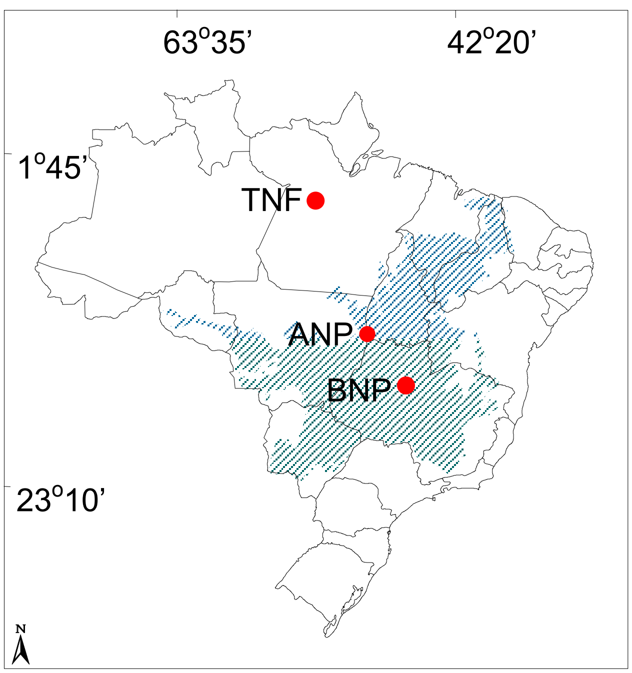

Figure 1. Location of the study sites, including Tapajos National Forest (TNF), Araguaia National Park (ANP), and Brasilia National Park (BNP), in Brazil. Hyperion scenes were acquired in the end of July, 2001 over these sites.

In Figure 2, the differences of AVHRR vs. MODIS and of ETM+ vs. MODIS reflectances are plotted against MODIS reflectance values.

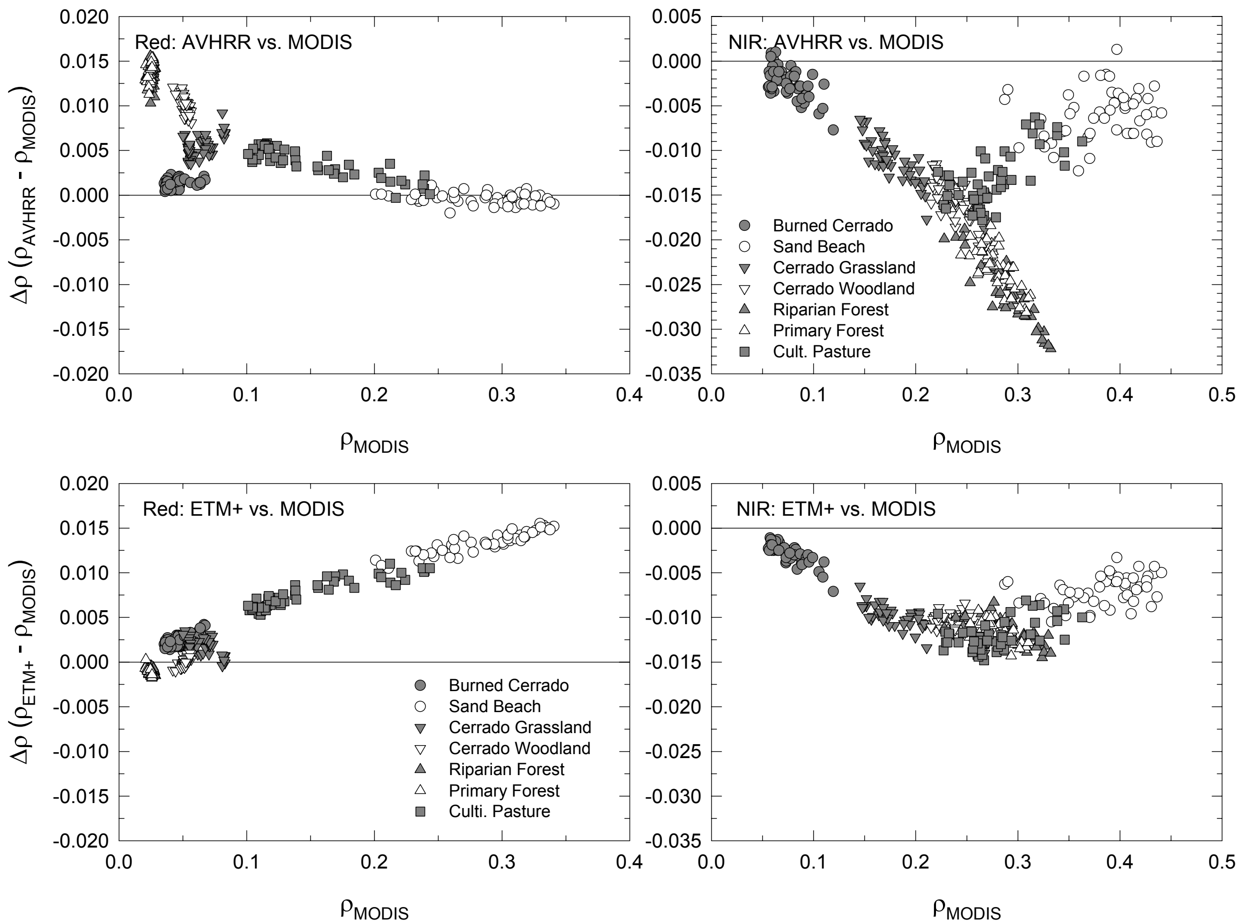

Figure 2. Differences of AVHRR vs. MODIS (top) and of ETM+ vs. MODIS (bottom) surface reflectances for red (left) and near-IR spectral bands (right).

In Figure 3, the NDVI differences of AVHRR and ETM+ to MODIS are plotted against the MODIS-NDVI values.

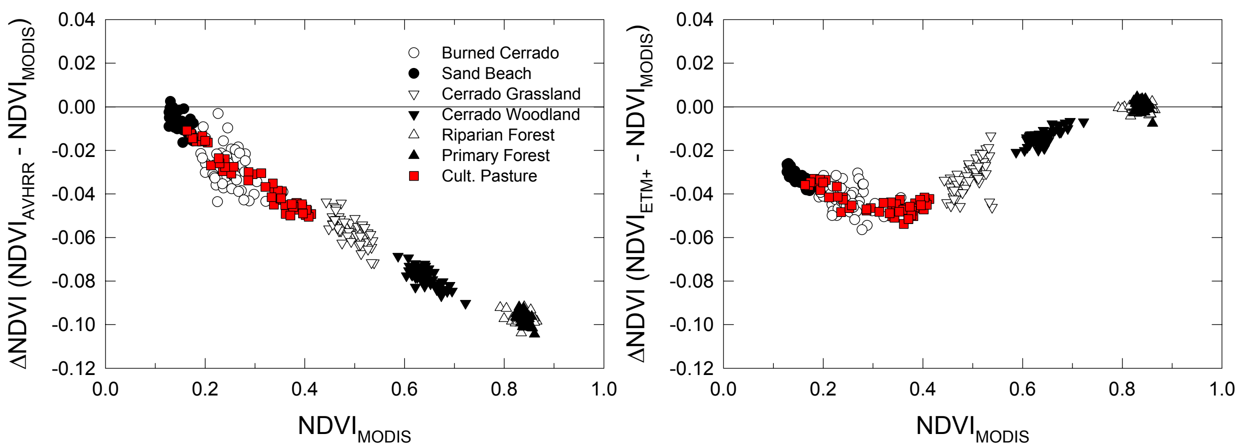

Figure 3. NDVI cross-sensor plots (differences) for AVHRR vs. MODIS (left) and ETM+ vs. MODIS (right).

As the standard AVHRR processing currently involves only partial atmospheric correction, the NDVI relationships were also examined for the AVHRR-NDVI computed from partial atmospherically-corrected reflectances and the MODIS-NDVI computed from total atmosphere-corrected reflectances (Figure 4).

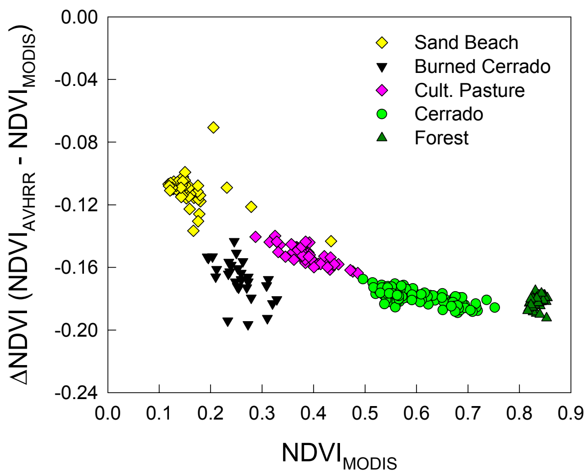

Figure 4. NDVI cross-sensor plots (differences) for AVHRR vs. MODIS. The MODIS-NDVI were computed from total atmosphere-corrected reflectances, while the AVHRR-NDVI were from reflectances corrected only for partial atmospheric effects.

Summary and Conclusions

The reflectances among the sensors investigated in this study were either linearly or curve-linearly related depending on the bandpasses. These relationships also showed strong land cover dependencies, i.e., the relationships were affected by both the greenness and brightness of the surface targets.

In general, NDVI relationships formed single relationships that were much less land cover-dependent than those for the reflectances. However, the NDVI relationships among sensors were neither linear nor unique and were found to exhibit complex patterns and dependencies on spectral bandpasses. From the radiometric point of view, an inclusion of the "red-NIR transitional" zone, a diagnostic spectral feature of photosynthetically-active vegetation (PV), to either red or NIR bandpasses is the "key" in producing the complex patterns in across-sensor VI relationships. From the biophysical point of view, inter-sensor VI relationships varied with land cover types and surface compositions. Thus, a prior knowledge of such ecosystem parameters as leaf area index (LAI) and soil brightness are needed for exact translation.

Atmospheric contaminations were found to increase the discrepancies and land cover dependencies of inter-sensor VI relationships, of which magnitudes depends both on level of atmospheric contaminations and on amount of green components (e.g., LAI). Other factors of cloud and BRDF-related influences might affect the resulting NDVI values to a much greater extent than spectral bandpass differences.