Quantifying Changes in Carbon Pools with Shrub Invasion of Desert Grasslands using Multi-Angular Data from EOS Terra and Aqua

PI: Mark Chopping   Montclair State University.
Co-PIs: Debra P. C. Peters, Albert Rango   USDA/ARS Jornada Experimental Range.
          John V. Martonchik   NASA/JPL.
          William J. Parton   Colorado State University.

Abstract -- In order to quantify total C storage in arid ecosystems it is necessary to map the extents of different grassland and shrubland community types, rather than relying solely on measures of vegetation abundance. However, it is inadequate to map communities at the combined grassland/shrubland level since large differences in C storage are expected both between different shrub types, particularly below-ground; and within the same community with differing shrub, grass/forb understorey and bare soil proportions. What is required might therefore be termed *precision community type mapping.* We intend to address the need to determine community type as well as reliably estimate the proportions of soil, grass and shrubs over the large extent of southwestern US arid lands using remote sensing which is the only technology at our disposal which is spatially and temporally comprehensive. Our goal is to test a multi-angle approach to provide parameters useful in the driving and validation of biogeochemical models for semiarid and arid grasslands of the southwestern US by exploiting multi-angle data from the NASA Earth Observing System (EOS) MISR and MODIS sensors. We assert that estimates of soil organic carbon, which potentially represents an important fraction of total C storage, can only be obtained through modeling with knowledge of vegetation type.

The launch of the NASA EOS Terra and Aqua satellites provides new opportunities for exploiting multiple view angle remote sensing techniques. The Multi-angle Imaging SpectroRadiometer (MISR) on Terra is designed specifically to look away from the nadir direction with nine multiple view angle cameras and a ~275 m footprint which is highly appropriate for mapping the heterogeneous communities of the southwestern US. The MODerate resolution Imaging Spectroradiometer (MODIS) on Terra and Aqua uses a more traditional revolving scan mirror to acquire spectral radiance measurements at ~250 m and also views off-nadir as a result of the wide swath. Multi-angle sampling of the land surface reflectance (bi-directional reflectance distribution function; BRDF) provided by MISR and/or MODIS allows inversion of models which describe and/or explain the anisotropy observed in surface radiation fields. Reflectance anisotropy may be exploited to obtain unique information on vegetation which is not available in the spectral, spatial or temporal domains, by inverting BRDF and canopy reflectance models and through clumping and scattering indices and metrics. We intend to make instrumental use of model parameters and metrics through hard classification, as well as physical interpretation of parameters where appropriate. Successful inversion of many BRDF models is hindered by the small range of sun and viewing angles; we will therefore combine data from both MISR and MODIS to provide an improved sampling in the angular domain.

We propose to investigate several different approaches to obtaining useful information on arid land vegetation via remote sensing in the angular domain, including: inversion of linear semi-empirical kernel-driven variant and RPV BRDF models; multi-angle metrics (ANIX, NDAX); clumping and structure indices (Structural Scattering Index). We will use red band reflectance data mapped to a 250 m grid from both instruments at multiple angles and the blue, green, and near-infrared bands from MISR at nadir to enhance spectral coverage. Red wavelength bi-directional reflectance data are most appropriate for BRDF model inversions because in these wavelengths absorption by plant photosynthetic materials and pigments is maximal and the single scattering approximation is more valid than in the near-infrared, where greater multiple scattering means that accurate modeling is more difficult.

Validation of mapped vegetation communities will be effected through comparison with published maps and literature, existing field collected data sets, and interpreted high resolution panchromatic and aerial imagery. The affiliation with the Jornada Experimental Range -- which is both a USDA, ARS research site, a NSF funded LTER site, and a NASA Land Validation Core Site -- we have access to three large soil carbon inventory databases which will also be used to assess our mapping results.