Albedo Response to Disturbance from Intergrating Landsat and MODIS Data

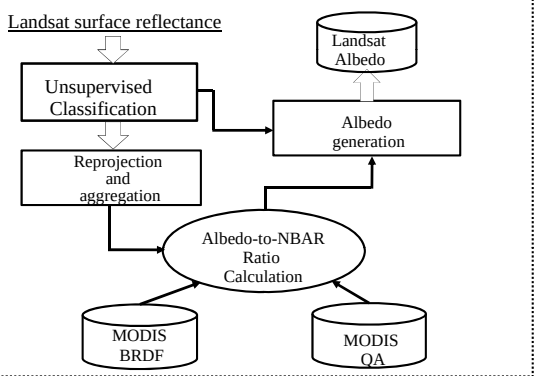
Yanmin Shuai[1,2], Jeffrey G. Masek[1], Feng Gao[3] , Crystal B. Schaaf[4,6] , Christopher A. Williams[5] , Zhuosen Wang[6]

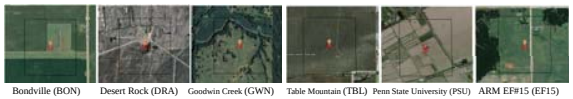
[1] Biospheric Sciences Branch (Code 614.4) NASA Goddard Space Flight Center, Greenbelt, MD 20771; [2] Earth Resources Technology Inc., 6100 Frost Place, Suite A, Laurel, MD 20707;
[3] USDA-ARS Hydrology and Remote Sensing Laboratory BARC-West Beltsville, MD 20705; [4]Environmental, Earth, and Ocean Sciences, University of Massachusetts Boston, Boston, MA 02125;
[5]Graduate School of Geography, Clark University, MA 01610; [6]Center for Remote Sensing, and Department of Geography and Environment, Boston University, Boston MA 02215

ABSTRACT

Numerous papers have highlighted how land-cover change and ecosystem disturbance alter the surface energy balance through changes in albedo, surface roughness, and evapotranspiration. In some cases, these surface changes may constitute a larger radiative forcing than those arising from associated carbon emissions. Past studies on post-disturbance albedo have been limited by the resolution of available MODIS data (500m), which is significantly coarser than the characteristic scales of ecosystem disturbance and human land use. Our project addresses this issue by creating high-resolution (30m) albedo maps through the fusion of Landsat TM/ETM+ directional reflectance with MODIS BRDF/Albedo (MCD43A) data. These maps permit trends in albedo to be evaluated at the characteristic scale of vegetation change (~1 ha). Our goals are to: (i) assemble a regional library of albedo values for IGBP land cover types; (ii) assemble time series of post-disturbance albedo from a latitudinal distribution of typical forest disturbance types (fire, insect damage, harvest); (iii) evaluate decadal trends in landscape albedo for "hotspots" of vegetation change; and (iv) assess the radiative forcing associated with historical (since 1700) and future (scenario-based) global land-cover change. Here we present recent results from the MODIS-Landsat fusion algorithm for 30-meter albedo retrieval, including validation from BSRN sites (Shuai et al, 2011, RSE). We will also present initial versions of the IGBP-type albedo look-up table (task i), and the BRDF look-up table for post-disturbance recovery based on data from the Pacific NW of the United States (task ii).

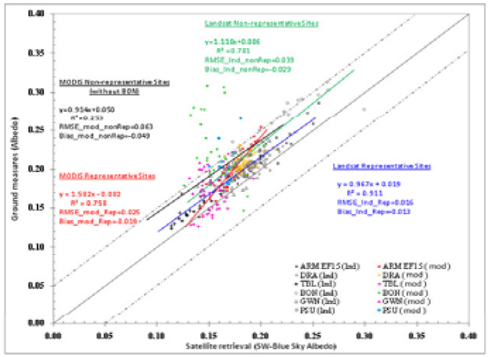
Landsat scale albedo retrieval and validation in BSRN sites





Bondville (BON) Desert Rock (DRA) Goodwin Creek (GWN) Table Mountain (TBL) Penn State University (PSU) ARM EF#15 (EF15)

Note: Landscape of ground validation sites within 30-m by 30-m Landsat TM-like (red square) and a 500-m by 500-m MODIS-like (black square) from *maps.google.com*

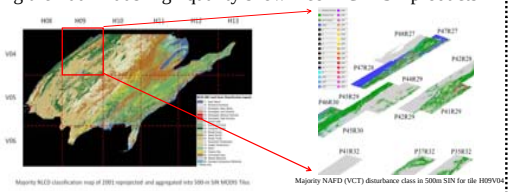


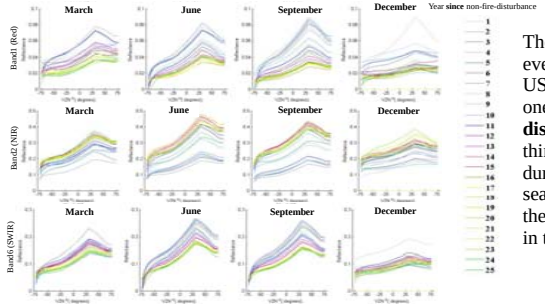
Scatter plot of actual shortwave albedo at 10:30AM from Landsat retrievals and at local solar noon from MCD43A albedo products versus the synchronous ground measures. The solid blue and green lines are the trend lines for Landsat representative and non representative sites by a linear regression, while the solid red and dark lines are for MODIS representative and non-representative sites respectively. The solid grey line is the one-to-one line and the dotted grey lines are ±0.05 units.

Evolution of BRDF During Recovery from Disturbance (Northwest US)

The BRDF evolution of evergreen forests after fire or non-fire disturbances is analyzed in the pacific NW of the United States using the 2001-2008 high quality snow-free MCD43A products for 500-m "pure" pixels.

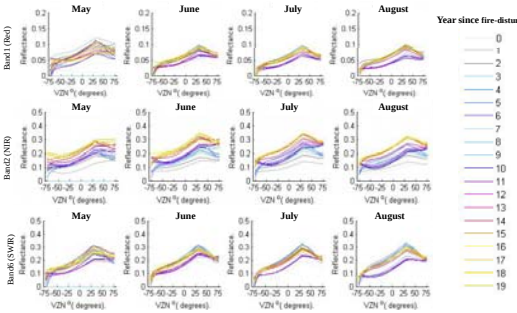
The presence of detectable fire or non-fire disturbances over 85%+ in the 500-m cell is determined by historical 30-m Vegetation Change Tracker (VCT) (Huang et al. 2009;2010) and Monitoring Trends in Burn Severity datasets (MTBS; http://www.mtbs.gov)





Snow-free BRDF shapes in the principal plane with 30 °Sun for the **non-fire-disturbed** evergreen forests in NW at MODIS band1 (upper), band2 (middle), and band6 (lower)

The gradual recovery of evergreen forests in the NW US (H09V04) resulting from a one-time **non-fire disturbance** (includes harvest, thinning, or insect damage) during 1985-2008 is captured seasonally with an increase in the NIR band and a reduction in the red & SWIR reflectance.



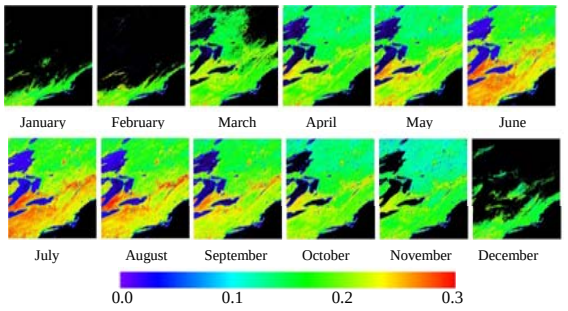
Snow-free BRDF shapes in the principal plane with 30 °Sun for the **fire-disturbed** evergreen forests in NW at MODIS band1 (upper), band2 (middle), and band6 (lower)

Recovery of **fire-disturbed** forest shows differences compared to the non-fire case (above). All spectral regions brighten for several years after the fire, possibly due to replacement of char with litter coupled with emplacement of herbaceous vegetation. Eventually the visible albedo will decrease as well, although this process may take several decades as the secondary forest canopy expands

"Pure" IGBP-class MODIS Albedo Values Incorporating 30m Land Heterogeneity

At MODIS resolution many land cover classes are mixed, particularly those dominated by human management. In this project, we are creating new IGBP-class look-up tables for albedo and BRDF based on identifying larger pure (homogenous) regions using Landsat data at 30m . We then extract high-quality MODIS albedo and BRDF samples for only those "pure" regions in order to isolate values specific to each land cover type. The figure below shows the first part of this process, the creation of an 11-year monthly albedo climatology using the median value from the MCD43 product.

h12v04, white-sky shortwave albedo, 11-year high quality median value



Next Steps

The project started in May 2011, and will complete work within three years. Next steps include:

(1) Applying the cover-type and post-disturbance BRDF values to Landsat reflectance time series from the Pacific Northwest and Southeastern US in order to evaluate regional changes in leaf-on albedo since 1985;

(2) Incorporation of snow-covered albedo values to enable evaluation of integrated annual albedo;

(3) Extension of these techniques to the rest of North America and other regions of the globe, including modeling historical and future albedo scenarios (1700-2100) associated with land use change using IPCC AR5 Global Land Use Harmonization (Hurtt et al, 2006, Global Change Biology).

(4) Continued validation using BSRN sites and 2011 campaign data from the Cloud Absorption Radiometer (CAR) flown over Howland (ME), Harvard Forest (MA), Bartlett Forest (NH), and the Florida Everglades.

Contact: Yanmin.Shuai@ertcorp.com; Jeffrey.G.Masek@nasa.gov

References: Yanmin Shuai,Jeffrey G. Masek, Feng Gao, Crystal Schaaf,(2011), An algorithm for the retrieval of 30-m snow-free albedo from Landsat surface reflectance and MODIS BRDF. *Remote Sensing of Environment*, doi:10.1016/j.res.2011.04.019