MODIS Collection 5 Land Cover Type and Land Cover Dynamics: Algorithm Refinements and Early Assessment

Damien Sulla-Menashe and Mark Friedl
Department of Geography and Environment, Boston University, 675 Commonwealth Avenue, Boston, MA 02215
http://www.bu.edu/geography

Abstract

The Moderate Resolution Imaging Spectroradiometer (MODIS) onboard NASA's Terra and Aqua spacecraft provides land surface data at global scales that are useful for a wide array of scientific applications related to land surface properties and processes. In the past year, land products from MODIS collection 5 reprocessing have become available. In this paper, we describe algorithm refinements and recent results from collection 5 reprocessing of the MODIS land cover type and land cover dynamics products (MOD12). Specifically, we summarize changes to the algorithms and data sets that are being used to characterize the geographic distribution and phenology of vegetation and land cover types at global scales. In collection 5, the MOD12 product is being produced at 500-meter spatial resolution using 8-day inputs from the MODIS normalized BRDF-adjusted (NBAR) product. The increased spatial and temporal resolution of the input data used to produce the MOD12 product represent significant steps forward and result in substantial improvements relative to the MOD12 collection 4 products. This poster describes specific changes to algorithms and input data that are being used in collection 5, and will provide preliminary assessments regarding changes in product quality.

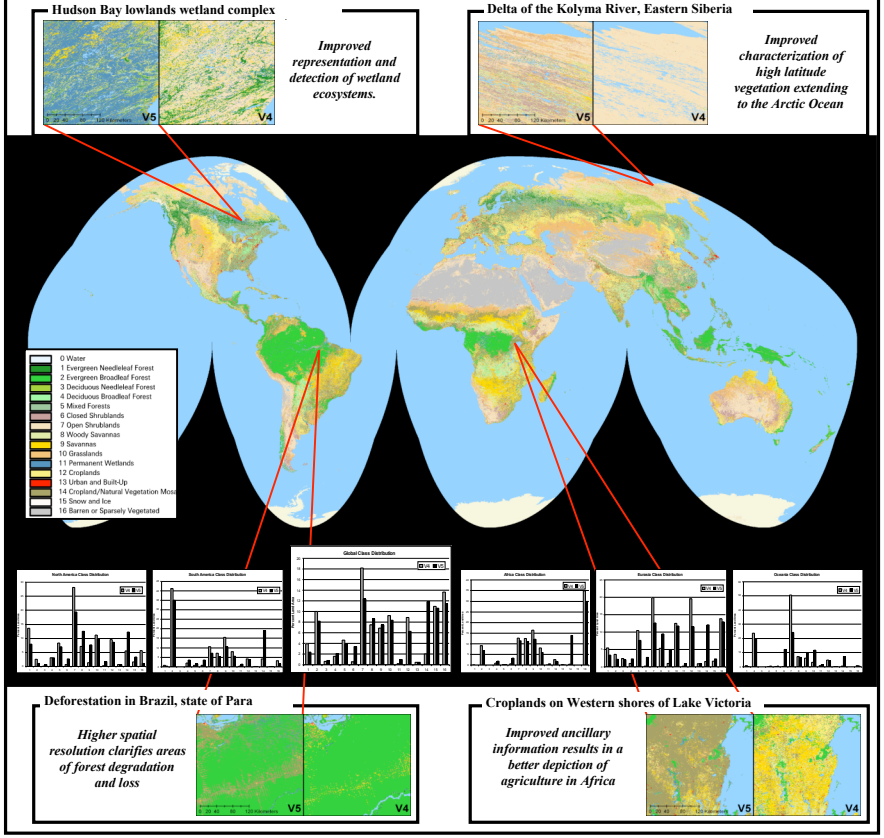
Algorithm Refinements

The Collection 5 MOD12 product will include a number significant changes and refinements. Most importantly, the C5 product will be based on input data with increased spatial and temporal resolution. In the case of land cover type, the algorithm now uses land surface temperature in addition to surface reflectance. These improvements increase the overall quality of the product by: (1) providing a more accurate representation of vegetation patterns at sub-kilometer scales, (2) through improved quality and frequency of measurements in areas of persistent cloud cover, and (3) by reducing misclassification due to mixed pixels and missing data. The most important of these changes are summarized in the table below.

Major Changes to the MOD12 Land Cover Type and Land Cover Dynamics Products (MOD12Q1 MOD12Q2)

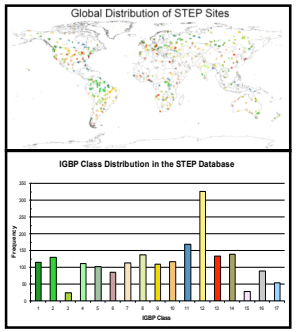
	V4	V5
Inputs	•32-day NBAR data (7 land bands) at 1-km resolution derived from two 16-day values. •32-Day EVI data at 1-km •Annual metrics (min, max, mean) for each of the above bands. •16-day EVI computed from NBAR data	•32-day NBAR (7 land bands), EVI and LST data at 500-m resolution derived from four 8-day values. •Annual metrics (min, max, mean) for each of the above bands. •8-day EVI computed from NBAR data
Ancillary Data	•MODIS V4 land-water mask •V4 urban mask •Prior probability layers based on Collection 3 data and ancillary data related global croplands intensity	•MODIS V5 land-water mask •Updated V5 urban layer •Prior probability layers based on Collection 4 data with inclusion of new agricultural intensity data
Algorithms	•Significant reliance on out-of-date prior probability layers •Ad hoc reduction of overestimated deciduous needleleaf forests and wetlands •Ad hoc screening for snow and gap filling for missing data	•Decreased reliance (weighting) on prior probability layers •Improved treatment/representation of deciduous needleleaf forests •Improved treatment/representation of wetlands •Improved gap filling and screening for snow
STEP Database	•Largely based on older TM5 data •Large sites with significant internal heterogeneity. •Inadequate quality control •Relatively poor and misrepresentative sampling in key areas	•Updated to more recent (2000+) imagery •Updated to conform to require-ments for 500-m data •Extensive quality control including editing and removal of bad sites •Augmentation of sites in under-represented areas and classes

Preliminary Results for Land Cover Type



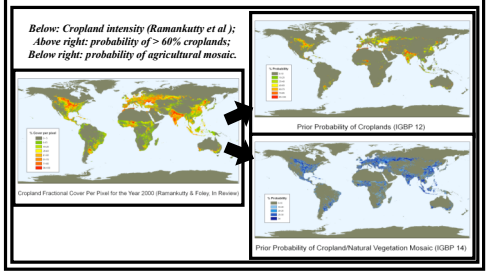
Refinements to the STEP database

- **The System for Terrestrial Ecosystem Parameterization (STEP) database provides training data for the MOD12Q1 land cover type product algorithm.**
- **In preparation for collection 5 the STEP database was analyzed and extensively revised to insure representative sampling of land cover. Specifically, we examined:**
  - **Geographic & ecological sampling based on biogeographic realms, global biomes from Olson et al. (2001), and country level statistics.**
  - **Outlier and error analysis based on PCA of raw NBAR data, annual EVI profiles, and measures of internal heterogeneity.**
  - **The distribution and sampling of agricultural sites using crop inventory data.**
- **Results from these analyses lead to the following changes to the STEP database:**
  - **Addition of wetland and forest sites in China; deciduous needleleaf sites in Siberia; forest sites in New Zealand; and agricultural sites in Sahelian Africa, Mexico, India, Canada, and New Zealand.**
  - **Reduction in size or removal of large sites such (e.g., large snow/ice sites in Greenland).**
  - **Re-labeling or removal of sites based on new sources of data including ancillary maps, high resolution imagery, or EVI temporal profiles.**
  - **Removal of sites that were internally heterogeneous, or mixed.**



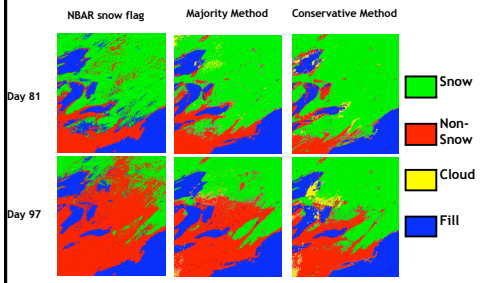
Updated Ancillary Data Layers

- **Ancillary data layers are used within the MOD12Q1 algorithm to aid classification results when data from MODIS do not effectively separate classes. These data are derived from a variety of sources including the Collection 4 MOD12Q1 product, agricultural intensity data, and the MODIS land water mask.**
- **A 150 km x 150 km moving window was used to compute the approximate regional frequency of classes based on MODIS collection 4 data; this provides local likelihoods for each class at each pixel.**
- **To prescribe the likelihood of agriculture or agricultural mosaic, we used a new data set from Ramankutty et al. (2008, in press, GBC; see below).**



Collection 5 Refinements to the Land Cover Dynamics Product

Refinements to the collection 5 land cover dynamics product (MOD12Q2) include changes to the algorithm and input data. Most importantly, 500-m NBAR data at 8-day intervals are being used to model land cover dynamics on seasonal time scales (phenology). As a result, the spatial resolution of the product has increased from 1-km to 500-m, and detection of phenological transition dates should be both more accurate. In addition, the algorithm used to produce collection 5 results includes a number of subtle changes that affect how missing data in NBAR data are treated, and how snow is both detected and accounted for in the algorithm (see below).



Snow info for tile h12v04 of day 81 and 97 in 2002. The left column is the snow flag provided with MODIS NBAR product. The middle and right columns are spatially aggregated MOD10A2 with majority and conservative methods, respectively. In the majority method, a 16-day 1-km pixel is marked as snow if the more than 50% of the 8-day 500-m pixels are marked as snow in MOD10A2. In the conservative method, a 16-day 1-km pixel is marked as snow if any 8-day 500-m pixels are marked as snow in MOD10A2.

Acknowledgements

This work was supported by NASA grant # NNG04HZ71C. We also gratefully acknowledge the many contributions by numerous individuals in recent years, especially Dr. Bin Tan and Dr. Xiaoyang Zhang, both of whom were instrumental in implementing and refining the MOD12 algorithms