Mapping Impervious Surfaces Globally at 30m Resolution Using Landsat Global Land Survey Data

Impervious surfaces, mainly artificial structures and roads, cover less than 1% of the world's land surface (1.3% over USA). Regardless of the relatively small coverage, impervious surfaces have a significant impact on the environment. They are the main source of the urban heat island effect, and affect not only the energy balance, but also hydrology and carbon cycling, and both land and aquatic ecosystem services. In the last several decades, the pace of converting natural land surface to impervious surfaces has increased. Quantitatively monitoring the growth of impervious surface expansion and associated urbanization has become a priority topic across both the physical and social sciences.

The recent availability of consistent, global scale data sets at 30m resolution such as the Global Land Survey from the Landsat satellites provides an unprecedented opportunity to map global impervious cover and urbanization at this resolution for the first time, with unprecedented detail and accuracy. Moreover, the spatial resolution of Landsat is absolutely essential to accurately resolve urban targets such as buildings, roads and parking lots. With long term GLS data now available for the 1975, 1990, 2000, 2005 and 2010 time periods, the land cover/use changes due to urbanization can now be quantified at this spatial scale as well.

In the Global Land Survey – Imperviousness Mapping Project (GLS-IMP), we are producing the first global 30 m spatial resolution impervious cover data set. We have processed the GLS 2010 data set to surface reflectance (8500+ TM and ETM+ scenes) and are using a supervised classification method using a regression tree to produce continental scale impervious cover data sets. A very large set of accurate training samples is the key to the supervised classifications and is being derived through the interpretation of high spatial resolution (~2 m or less) commercial satellite data (Quickbird and Worldview2) available to us through the unclassified archive of the National Geospatial Intelligence Agency (NGA). For each continental area several million training pixels are derived by analysts using image segmentation algorithms and tools and then aggregated to the 30m resolution of Landsat. Here we will discuss the production/testing of this massive data set for Europe, North and South America and Africa, including assessments of the 2010 surface reflectance data. This type of analysis is only possible because of the availability of long term 30m data sets from GLS and shows much promise for integration of Landsat 8 data in the future.
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Introduction

Since about 2000, the U.N. estimates more people live in cities than rural areas. Higher urban growth rates are expected in the developing world in the next 50 years. Cities still represent a relatively small “footprint” globally (~3% of land area).

However, the process of urbanization is most often irreversible, modifying carbon, water, energy cycles at various spatial scales.

New global scale data sets from Landsat (GLS: Global Land Survey) provide great opportunities to map and monitor urbanization at the appropriate spatial scale, with future integration of Landsat 8 data to the present.

Project Objectives:

1. Produce Global, 30m resolution surface reflectance data from Landsat for 2010 using Global Land Survey Data.
2. Produce the first Global scale, 30m resolution percent impervious cover data sets for 2000 and 2010 and assess areas of significant urbanization in the 2000-2010 period.

Our overall approach is essentially a supervised classification approach using a continental global archive of very high resolution commercial satellite data for training.

Methods

Hierarchical Image Segmentation Functions/Tools:

- All subsets are then batch processed using the HSeg Software which is a form of region growing segmentation that directly forms a segmentation hierarchy based on user interaction. We have developed an in-house tool called HSegLearn which allows spatially disjointed region classes to be merged and results are continuously updated through a ratio of two cubic polynomials. All required coefficients are embedded in the metadata of the high resolution data.

- Our overall approach is essentially a supervised classification approach using a continental global archive of very high resolution commercial satellite data for training.

Results

- The data are then aggregated to 30m resolution and matched to the GLS-2010 surface reflectance data for training.

- The training pixels for the entire continent (~2.63M for Europe, ~0.8M for North America, ~1.3M for South America, and ~0.5M for Africa) are used within the Cubist Regression Tree algorithm to create percent impervious cover product for each GLS-2010 scene (see Fig. 4).

- Our overall approach is essentially a supervised classification approach using a continental global archive of very high resolution commercial satellite data for training.

Progress & Status

- Processing of 855 Landsat TM and ETM+ data to surface reflectance for GLS-2010 (Figure 2)
- Developed tools to significantly facilitate the work of analysts during production of training data using HSeg
- Enhanced the process and quality of training significantly compared to previous methods used by the PIs
- Ordered and reviewed a global archive of over 1,800 high-res images
- Completed training for Europe, North America, Africa, and South America (See Fig. 5)
- Exploring the uses of GIS tools, data, and services as an effective tool for QA and also for identification and removal of false positives
- Testing methods for improving training data quality using regression and decision tree classifiers, outlier identification and filtering, etc. (Our training data is dominated by low impervious cover samples which can bias regression trees.)
- Developed and executed QA tools and metrics for training data.
- Automated image orthorectification for better co-registration of training and GLS-2010 data.

Next Steps

- Apply continental masks of water, shadow, cloud, and snow.
- Automate training data outlier removal.
- Reduce commission errors through ancillary data.
- Complete and assess continental scale results for Europe/North America.
- Create training data for Asia and process Australia in Hseg.

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References