Progress Towards Global Impervious Cover Products Using GLS-2010 Data

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Introduction

- Since about 2008, the U.N. estimates more people live in cities than rural areas. Higher growth rates expected in developing world in next 30 years.
- Cities still represent relatively small 'footprint' globally (~3% of land area).
- Process of urbanization is most often irreversible, modifying carbon, water, energy cycles at various spatial scales.
- New data sets from Landsat and NGA provide great opportunities to map and monitor urbanization at the appropriate spatial scale, and with a look to future data sets from Landsat 8.

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.

Methods

Obtain High Resolution Imagery from the NGA

High-resolution imagery is ordered through the NGA's unclassified WARP database. We look for scenes that are cloud free, between the years 2009 and 2011, represent periods of leaf-on vegetation, with view angles close to nadir, and high sun angles.

Review Imagery Order in ArcGIS 10.1

Scenes are organized and double checked using ArcGIS 10.1. Using ArcGIS software allows us to view and check the scenes in fine detail to assure the above criteria is met. Images should also be spatially distributed to represent the geographical variations present in the landscape. Continent, country, and city are visually determined and organized. In addition, UTM zones are noted for the next step.

Re-Project and Subset in ENVI

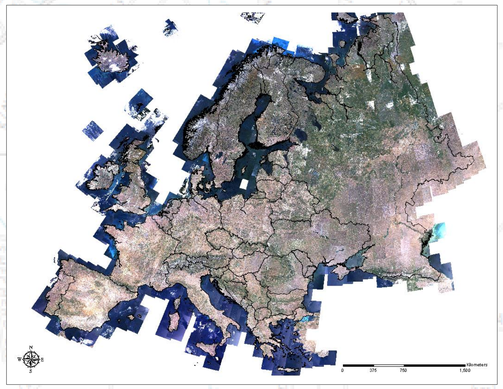
Each image is then pre-processed using ENVI 5.0 software. Image format is changed from NITF to GeoTIFF and re-projected to the proper UTM coordinate zone. Each newly re-projected GeoTIFF is then subset into three 2500 x 2500 pixel scenes.

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* that allows spatially disjoined region classes to be merged and results are continuously updated as the analyst submits binary selections of either impervious or non-impervious features. *HSegViewer* is used to fine-tune classifications by allowing the user to manipulate the labeling of segmentation hierarchies and as a final QA tool. Errors commonly encountered include misclassified roads, open pit mines, bare fields, etc.

- 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 (~2.4M for Europe) are used within the Cubist regression tree algorithm to create %impervious cover product for each GLS-2010 scene (see Fig. 3).

Results



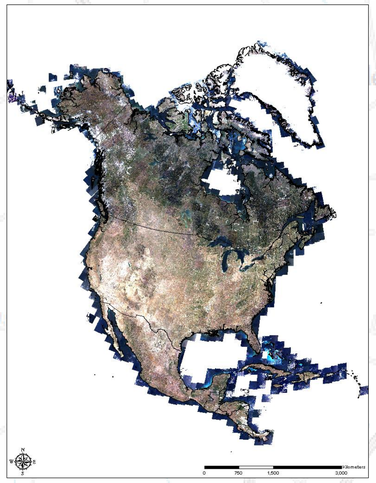


Figure 1. GLS-2010 Landsat Surface Reflectance mosaics over Europe and North America as processed by the Global Land Cover Facility (GLCF) at UMD. Europe contains a total of 832 images, while North America contains 1652 images.

Figure 2. NGA training sets for Jedlins, Poland (Top) and Glasgow, Scotland (Bottom). These images illustrate the impervious cover training data generation process. Very high spatial resolution Quickbird or Worldview-2 NGA imagery is classified and interpreted into impervious (green) and non-impervious (black) classes using Hierarchical Image Segmentation. The interpreted data are then aggregated to 30m resolution to derive %impervious cover training pixels.

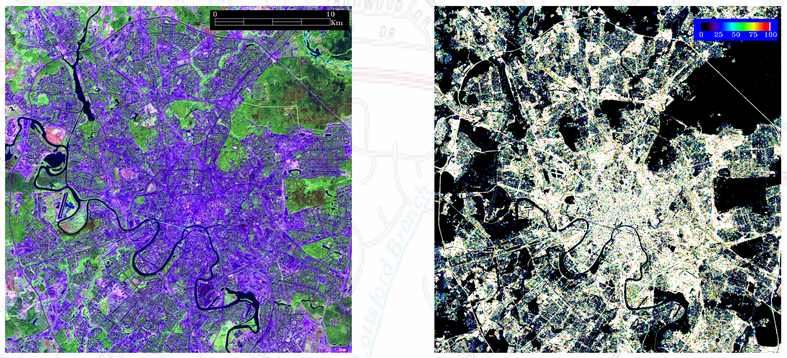


Figure 3. GLS-2010 Surface Reflectance subset over Moscow, Russia (Left). Derived %impervious cover results for Moscow (right) using ~2.4M training pixels from NGA data over Europe and Cubist regression tree. Results over principal cities are quite good but errors of commission over bare fields and crops are still a challenge due to phenology variations in the GLS-2010 imagery.

Progress/Status

- We had to give up on our attempts to use pre-processed NGA archive called 'CitySphere" because of data artifacts and lack of spectral data.
- We have processed 8555 Landsat TM and ETM+ data to surface reflectance for GLS-2010 (Figure 1).
- We have developed tools to significantly facilitate the work of analysts during production of training data using *Hseg*.
- The process and quality of training has been significantly enhanced over previous methods used by PIs.
- A global archive of NGA data has been ordered with training for Europe and North America complete and work beginning for Africa (See Fig. 4).
- We have been exploring the uses of GIS tools/data/services as an effective tool for QA but also for identification/removal of false positives.
- We have been testing methods for improving training data quality using regression/decision tree classifiers, outlier identification/filtering, etc… Our training data is dominated by low impervious cover samples which can bias regression trees.

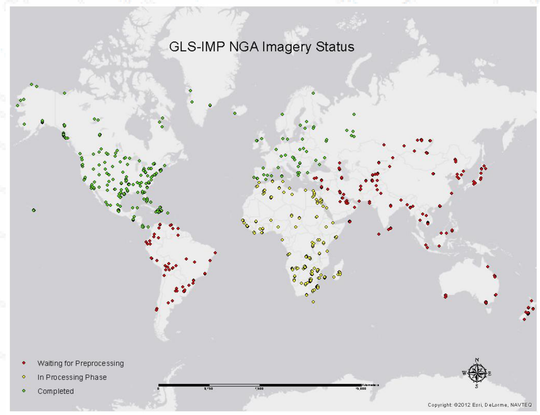


Figure 4. Status of training data selection and processing for the GLS-IMP Project. Over 700 Quickbird and Worldview-2 scenes have been acquired to date.

Next Steps

- Developing QA tools and metrics for training data.
- Developing automation of image orthorectification for better co-registration of training and GLS-2010 data.
- Continental application of water, shadow, and cloud/shadow, water and snow masks.
- Automation of training data outlier removal.
- Reduce commission errors through ancillary data.
- Complete and assess continental scale results for Europe/North America.
- Training for Africa, Asia, S. America and Australia.

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