

DEVELOPMENT OF 2016 NATIONAL IMPERVIOUSNESS PRODUCT

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ABSTRACT

The U.S. Geological Survey (USGS) National Land Cover Database (NLCD) has been developed to provide consistent land cover products for the nation since 2001. The database includes land cover, percent impervious surface, and percent tree canopy. The percent impervious surface area (ISA), which was estimated with satellite imagery and represents the fraction of impervious area in a 30 m grid, has been used to quantify urban land cover types and extents. Changes of land cover and impervious surface that have occurred during these 5-year intervals since 2001 are also provided.

This study focused on new strategies that have been developed for producing NLCD 2016 imperviousness product. The method updates ISA change following Landsat footprints using both NOAA's VIIRS and Landsat 8 images in circa 2016. The method has been applied in five different geographic locations in the United States. Analyses of ISA changes associated with urban developments in these five pilot areas have also been performed.

Index Terms— Impervious surface, urban land cover, NLCD, Landsat

1. INTRODUCTION

More than half of the world's population has been living in urban center since 2008 [1]. Associated with the population growth are the expansions of urban land use and land cover around the world. Urban land cover is an important component of regional and global environmental change and has significant implications for a range of ecological, biophysical, social, and climate consequences. The spatial, temporal, and sustainability-related qualities of urbanization are important for understanding the shifting and complex interactions between urban development and climate change. With consideration of rising levels of urbanization, a growing proportion of the world's population is facing the challenge of climate change and change impacts in urban areas [1].

Urban growth, which is one of the most important trends on earth, usually lasts decades and often results in deterioration of natural vegetation and environmental conditions associated with complex development forces. As a consequence of urban growth in the last several decades, a

significant amount of natural landscape has been converted into anthropogenic impervious surface in the United States [2]. Impervious surface has been recognized as the most prominent stressor for the ecological conditions in watersheds. Accurate spatial extent of impervious surface and its temporal change information is critical for assessing variations of urban land cover and associated ecological and climatic effects.

Satellite remote sensing data acquired from medium resolution satellites (e.g., Landsat) have provided repetitive and consistent observations of the terrestrial surface across large areas over time. These datasets have been widely used to monitor urban land cover change at both local and regional scales. It is still challenge to clearly determine urban extents and structures by using discrete classification methods along with medium resolution remote sensing data in part because of highly heterogeneous features of urban land cover. Most urban areas, especially in low intensity development areas, exhibit sub-pixel characteristics that mix impervious surface with other land covers (e.g. grass and trees) in medium resolution satellite imagery. However, the urban landscape can be treated as a continuum while using modeling techniques to extract urban characteristics. Percent impervious surface area (ISA) estimated from satellite data can be used to quantify urban extent and has been produced and updated in every five years by the USGS NLCD since 2001 [3].

This study focuses on (1) the development of new strategies for producing USGS NLCD 2016 imperviousness product using both Landsat and VIIRS images; (2) the implementation of the method to quantify impervious surface variation and associated land cover change between 2011 and 2015 in five areas in the United States.

2. DATA AND METHOD

Landsat 8 imagery in 2015 was used as the primary data source to estimate impervious surface. In each Landsat image, bands 2 to 7 were used. The NOAA VIIRS nighttime lights imagery in 2015 was chosen to create training data and refine the final product. Therefore, the cloud-free annual average of VIIRS images were selected and converted from the original 750 m to 30 m to match Landsat resolution.

The algorithm developed here was evolved from an early prototype proposed for updating the USGS NLCD

2006 and 2011 impervious surface products [4]. The new approach consists of three major steps: creation of training data, regression tree modeling, and final product refinement. In step I, the 2015 VIIRS imagery in 30 m was subset to each Landsat path and row. We then intersected the VIIRS imagery with the NLCD 2011 impervious surface product to exclude low density imperviousness outside urban and suburban centers. These impervious zones in the urban core areas were considered stable and were used as reliable training datasets. Ten training datasets, from one having a relatively larger urban extent to one having a relatively smaller extent, were produced using ten different thresholds of VIIRS imagery. In step II, each of the ten training datasets combined with 2015 Landsat imagery was separately applied with regression tree algorithms to build up regression tree models and produce ten different ISA estimates. Generally, both existing and new urban areas have relatively stable magnitudes in ISA estimates or smaller coefficients of variation. In step III, the 2015 ISA product and 2011 ISA synthetic imperviousness estimates were used to refine the new growth estimates. The 2011 ISA synthetic estimates were produced from regression tree model using a relatively larger and a relatively smaller urban extents defining by 2011 the U.S. Air Force Defense Meteorological Satellite Program (DMSP) nighttime light images [4]. These synthetic products were produced in the NLCD 2011 impervious surface production. After these steps, estimates of the 2015 new impervious surface and the 2015 modified impervious surface that has higher percent imperviousness in 2015 than that in the 2011 existing impervious surface area were produced.

3. RESULTS

Five pilot areas that are covered by five Landsat footprints including p16/r40 in Orlando, Florida, p21/r32 in Indianapolis, Indiana, p30/r27 in Fargo, North Dakota, p27/r37 in Dallas, Texas, and Boise, Idaho have been tested for the new algorithms. Generally, increases of ISA associated with urban land cover expansions in the region were directly estimated. Figure 1 shows the example from the test results in the Orlando area. Figure 1 (a) and (b) show 2015 Landsat image and 2011 impervious surface. The enlarged Landsat image illustrates new urban developments on the south edge of existing urban (c). The new growths of ISA were captured as residential developments in the area (d). Our preliminary analysis suggests that the method is stable and results are consistent by capturing new urban growths in all pilot areas.

4. CONCLUSIONS

Our preliminary results from the five pilot areas suggest that urban land cover change between 2011 and 20015 are quantified appropriately using the new approach with Landsat 8 and VIIRS images in a cost effective and accurate

way. The method is capable to be used to produce NLCD 2016 impervious surface product for the nation.

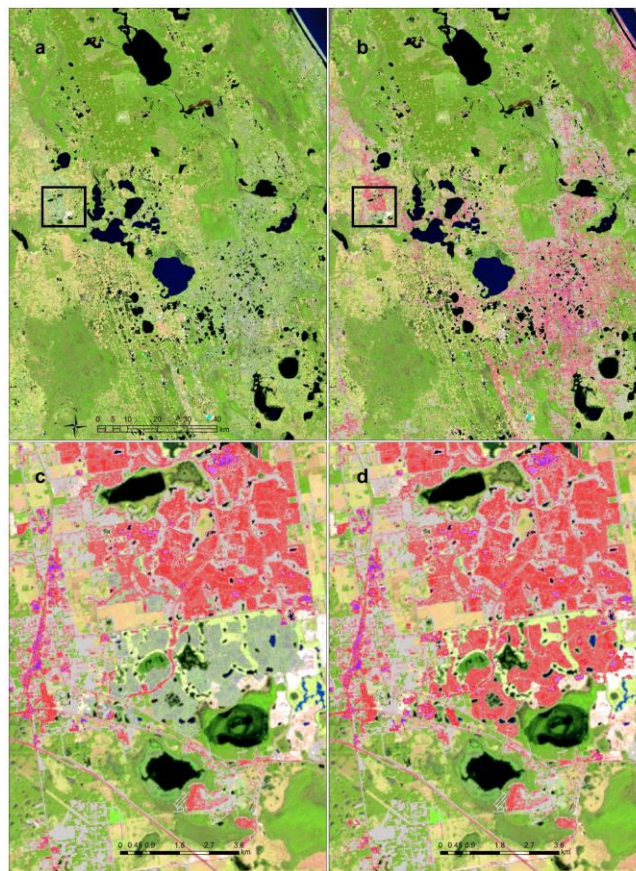


Figure 1. Landsat 8 image in 2015 (a), Landsat 8 image and 2011 impervious surface (b), 2011 impervious surface in the highlight area shown in (a) and (b) (c), and 2011 and 2015 impervious surface in the same highlight area (d).

5. REFERENCES

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