DI

IMAGE PROCESSING TO BUILD A MULTI-TEMPORAL VEGETATION ELEVATION MODEL (MTVEM) OF THE GREAT LAKES BASIN (GLB)

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EXECUTIVE SUMMARY

Deriving ecosystem characteristics from stereo imagery has been used for decades, yet frequent 3D digital mapping and monitoring has not been feasible until very recently. By more frequently monitoring surface changes in the vegetation throughout the growing season in the Great Lakes Basin with satellite remote sensing techniques, land managers will be supported with new, enhanced information to address emerging stand-to-landscape scale changes in ecosystem habitats. The amount of data in a study area of this size needed to be processed and analyzed is well beyond those available from academic, private, and government systems. This computational reality is precisely why we need a leading-edge petascale resource such as Blue Waters. The results from this project will enable scientists to understand their land with greater detail in three dimensions, thereby making management, conservation, and protection of important ecosystems as modern and effective as possible, which will enhance the nation's natural resources for future generations.

RESEARCH CHALLENGE

Ecosystem management requires knowing the type, size, structure, and density of vegetation over time. These important features need to be repeatedly mapped. Stereo submeter, optical satellite imagery, and derived surface vegetation models can be used to better characterize these features, and their changes over time, with the added dimension of height. High-resolution vegetation surface canopy mapping over large geographic regions, such as the Great Lakes Basin (GLB), has never been obtained from either aerial or satellite surveys. Additionally, the binational management (Canada and U.S.) of the GLB limits consistent, repeatable coverage by either country working independently. While a few scattered vegetation surface models exist from expensive airborne-active laser sensors (LiDAR) within the GLB, these datasets represent a single date and were not planned as continuous, basinwide acquisitions. Not having this information limits the kind of science that can be done to address the multitude of questions that surround the ecosystems of the GLB.

The question remains: How are the ecosystems of the GLB changing and what can we, as a society, do about it? Continuous monitoring of surface elevation will detect both natural changes (such as flooding, forest blowdown, fire, insects, and disease outbreaks) and anthropogenic changes (such as harvest and land cover change). Further, MTVEM will improve habitat and biological modeling. Finally, MTVEM will be used binationally to better visualize canopy change in forest habitats and freshwater wetland resources within the Great Lakes Basin.

METHODS & CODES

We currently have over 8,000 satellite image stereo pairs available and we estimate there will be an additional 5,300 pairs to be collected over the next 18 months, totaling about 13,300 image stereo pairs. Each stereo pair task is run on a single node, submitted in batches of 2 to 8 tasks per job. Complete processing of one stereo pair to 2m takes on average about 36 node hours, totaling about 483,590 node hours. We are adding ~10% time in addition for unforeseen events. Thus we asked for an allocation of 540,000 node hours. We will prioritize images based on science value to fit into our allotment, where the primary concentration is on the Great Lakes Basin but will extend temporal and geographical footprint as efficiencies and capacities improve.

RESULTS & IMPACT

As the data are processed, the resulting surface canopy models will become openly available through partner's online distribution systems, such as NOAA's Digital Coast and GEOSS Portal (www.geoportal.org). The final product, a seamless and registered surface elevation model (MTVEM) of the GLB, will enable a large range of science activities at substantially higher resolution than currently available. These canopy maps and change-detection products will provide positional accuracies of less than a couple meters with added ground control points. We have processed our entire archive of satellite image stereo pairs once. We are assessing change in priority GLB areas where LiDAR digital surface models from 2011 (DSM) are available (Figs. 1 and 2). Both gains and losses in vegetative cover over the five-year difference in the acquisition were detected in these examples. In addition, we are able to begin looking at seasonal differences by processing surface models from satellite stereo image pairs from within a single growing season. These preliminary results show great promise for providing valuable data to a myriad of coastal and terrestrial ecosystem science research questions that need to be addressed across the entire GLB.

WHY BLUE WATERS

Stereo satellite imagery allows for the generation of highly accurate surface elevation models and we have already tasked stereo-mode acquisition through Digital Globe over the entire GLB. Processing of this dataset will require an allocation well beyond those available from most academic, private, and government HPC systems, including the standard XSEDE allocations, which is precisely why the leading-edge petascale resource Blue Waters is necessary to address this research.

PUBLICATIONS AND DATA SETS

DigitalGlobe (2016), WorldView-3 scene 104001001C179100, Level Standard 2A, DigitalGlobe, Longmont, Colorado, 04/30/2016.

DigitalGlobe (2016), WorldView-3 scene 10400100227DC800, Level Standard 2A, DigitalGlobe, Longmont, Colorado, 10/03/2016.

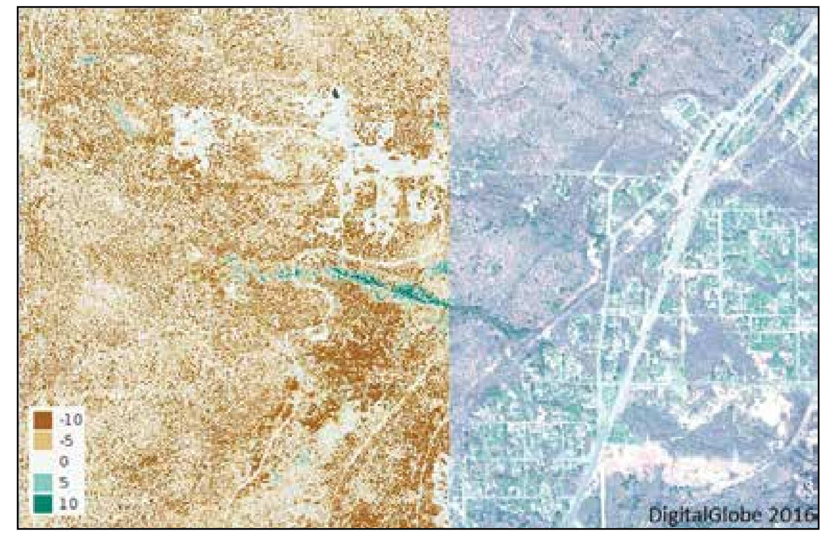

Figure 1: Duluth, Minn. On the left is a digital surface model difference map, using a LiDAR-derived surface model acquired in Spring 2011 and submeter stereo imagery-derived surface model from Spring 2016. The optical image on the right is from the same acquisition as the digital surface model in Spring 2016. Imagery courtesy of DigitalGlobe and the NextView program.

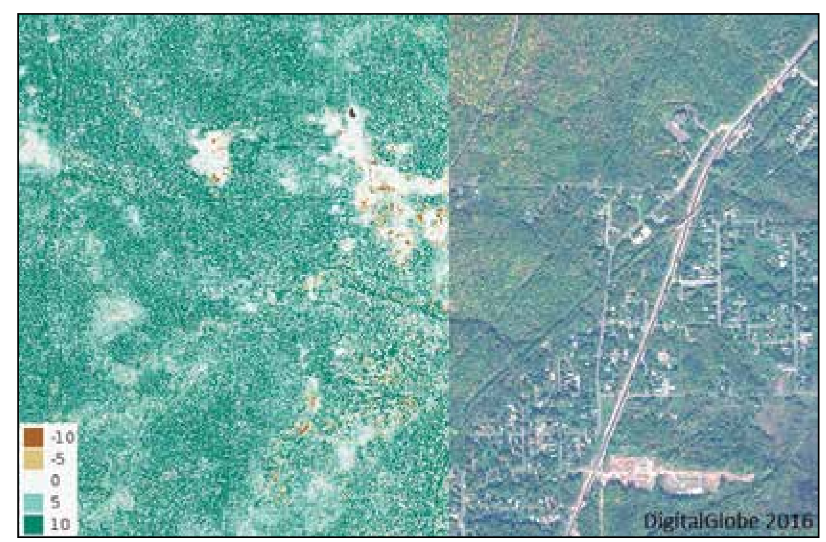

Figure 2: Duluth, Minn. On the left is a digital surface model difference map, using a LiDAR-derived surface model acquired in Spring 2011 and submeter stereo imagery-derived surface model from Fall 2016. The optical image on the right is from the same acquisition as the digital surface model in Fall 2016. Imagery courtesy of DigitalGlobe and the NextView program.