DI

IMAGE PROCESSING TO BUILD A MULTI-TEMPORAL VEGETATION ELEVATION ECOSYSTEM MODEL OF THE GREAT LAKES BASIN

Allocation: GLCPC/540 Knh
PI: Jennifer Corcoran[1]
Co-PIs: Brian Huberty[2], James Klassen[3], Keith Pelletier[1]
Collaborators: Paul Morin[1], Joe Knight[1], Laura Bourgeau-Chavez[4]

[1]University of Minnesota, Twin Cities
[2]U.S. Fish & Wildlife Service
[3]SharedGeo
[4]Michigan Tech Research Institute

EXECUTIVE SUMMARY

In 2017, the research team began acquiring, processing, and creating high-resolution, Multi-Temporal Vegetation Elevation Ecosystem Model (MTVEEM) maps across the entire Great Lakes Basin (GLB) where stereo, submeter, optical satellite imagery had been acquired over the last 15 years. This year, we have continued processing newly acquired imagery and adding processing steps to monitor changes in ecosystems over time, providing a new, essential data set that is otherwise not available to many fields of science and natural resource managers. The information we are generating will improve both our understanding of the complex processes at work in the GLB as well as our ability to forecast and mitigate adverse changes to the world's largest freshwater ecosystem. The amount of data to process and analyze for the GLB is well beyond the resources available from most academic, private, and government systems, and this computational need can only be addressed with a leading-edge petascale resource such as Blue Waters.

RESEARCH CHALLENGE

Ecosystem management requires knowledge of 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), is unprecedented for aerial or satellite surveys. Additionally, the binational management (Canada and United States) 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 data sets represent single time points and were not planned as continuous, basinwide acquisitions. Having high-resolution, multi-temporal information in three dimensions enables the kind of science that can address a multitude of critical questions that surround the ecosystems of the GLB.

The research questions remain: 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 from flooding, forest blowdown, fire, insects and disease outbreaks) and anthropogenic changes (such as harvest and land-cover change). Further, MTVEEM will improve habitat and biological modeling. Finally, MTVEEM will be used binationally to better visualize canopy change in forested habitats and freshwater wetland resources within the GLB.

METHODS & CODES

Stereo-mode acquisition through Digital Globe over the entire GLB started in 2016 and will continue through 2019 as clouds and other higher tasking priorities permit (Fig. 1). In 2017, we processed over 83,000 stereo pairs, where each job consisted of converting the input imagery into a standard format (GeoTIFF) and then calling the elevation extraction software (SETSM) [1]. We expect 50,000 additional satellite image stereo pairs for 2018. Each stereo pair task is run on a single node, submitted in batches of 2 to 100 tasks per job to the low-priority queue to maximize scheduler throughput. Complete processing of one stereo pair to 2m takes an average of 12 node hours (charged as six node hours due to using the low-priority queue), totaling 300,000 node hours. Additionally, we estimate it will take 150,000–200,000 node hours to process ortho-images and explore producing classifications based on the total number of image pairs we will have in hand.

RESULTS & IMPACT

As the data are processed in 2018, the resulting surface canopy models will be openly available initially through the University of Minnesota. Other partners' online distribution systems, such as NOAA's Digital Coast and the Great Lakes Observing System, will also be used. The final product, a seamless and registered surface elevation ecosystem model (MTVEEM) of the GLB will enable a large range of science activities at substantially higher resolution than currently available (current status shown in Fig. 1). These canopy maps and change detection products will provide positional accuracies of less than a couple meters with the added ground control points. We are assessing semidecadal changes in priority GLB areas where LiDAR-derived digital surface models

Figure 1: Great Lakes Basin digital surface model (DSM) production status as of March 2018. The source of the stereo imagery used to produce these DSMs span the archive, starting in about 2008 to early 2018. (2018 DigitalGlobe NextView License.)

from six to nine years ago are available. We are also beginning to look at intraseasonal differences by processing surface models from satellite stereo image pairs within a single growing season (see example of a blowdown event in Fig. 2). These preliminary results show great promise for providing valuable data to myriad coastal and terrestrial ecosystem science researchers and decision-makers across the entire GLB [2,3].

Our primary concentration will continue to be the GLB, with extended temporal and geographical footprints as efficiencies and capacities improve. Though we will continue to make significant progress in the GLB, this year's reallocation will also allow in-depth explorations of habitat types and terrain characteristics beyond our pilot study areas. This will allow us to adjust processes and perform quality control checks to enable scaling to much larger geographic regions, such as all of North America. With any remaining processing hours, the project may start half-meter MTVEEM processing, which has already been tested.

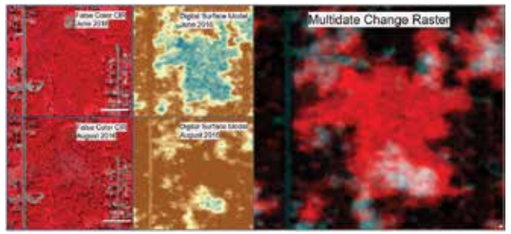

Figure 2: Near Duluth, Minn. False color-infrared images (left), corresponding digital surface models (DSM) (center), and difference map derived from a subtraction of the two DSM dates (right). (2018 DigitalGlobe NextView License.)

WHY BLUE WATERS

Stereo satellite imagery allows for the generation of highly accurate surface elevation models. We have already tasked stereo-mode acquisition through Digital Globe over the entire GLB. Each stereo pair is about 1.25 GB and the total number of pairs processed to date is about 83,000, soon to exceed 100,000. The amount of stereo imagery in a study area the size of the Great Lakes Basin and the computational burden to process each of these image pairs is well beyond those available from academic, private, and government systems. This is precisely why we need a leading-edge petascale resource such as Blue Waters.

PUBLICATIONS & DATA SETS

DigitalGlobe, WorldView-3 scene A 104001001E4FD500; B 104001001D127E00, Level Standard 2A, DigitalGlobe, Longmont, Colo., 06/08/2016.

DigitalGlobe, WorldView-3 scene A 1040010021C77D00; B 1040010020D20300, Level Standard 2A, DigitalGlobe, Longmont, Colo., 08/03/2016.