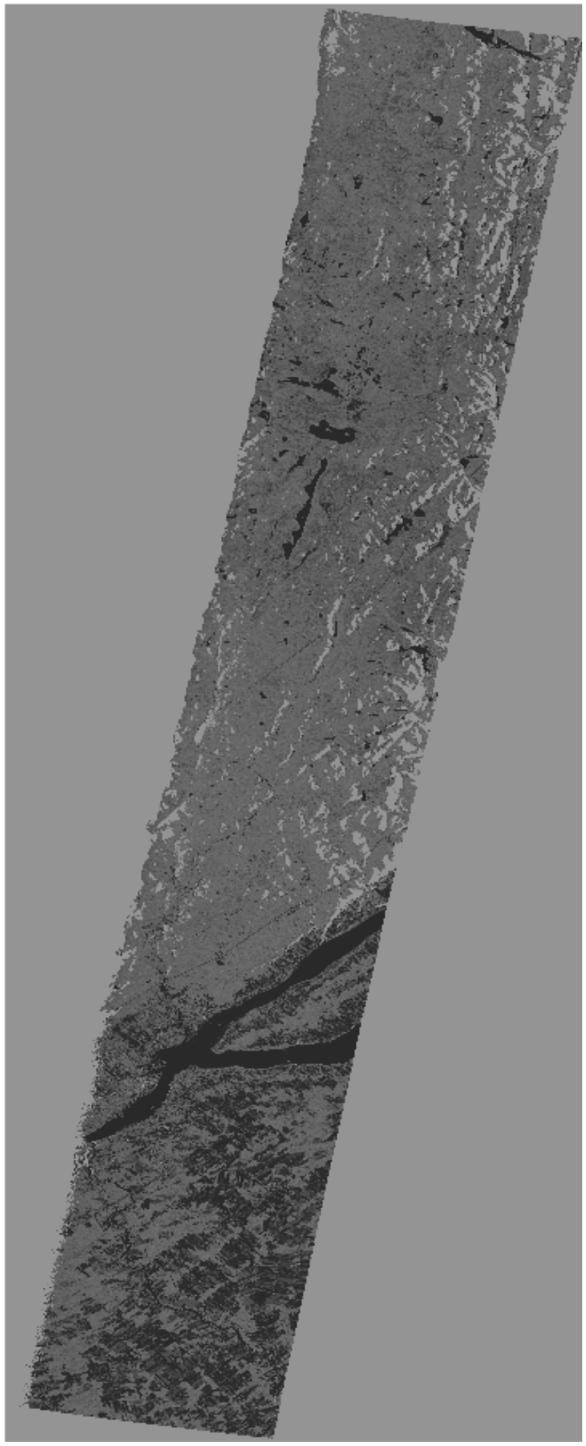
3D Vegetation Mapping Using UAVSAR, LVIS, and LIDAR Data Acquisition Methods



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Abstract

The overarching objective of this ongoing project is to assess the role of vegetation within climate change. Forests capture carbon, a green house gas, from the atmosphere. Thus, any change, whether, natural (e.g. growth, fire, death) or due to anthropogenic activity (e.g. logging, burning, urbanization) may have a significant impact on the Earth's carbon cycle. Through the use of Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) and NASA's Laser Vegetation Imaging Sensor (LVIS), which are airborne Light Detection and Ranging (LIDAR) remote sensing technologies, we gather data to estimate the amount of carbon contained in forests and how the content changes over time. UAVSAR and LVIS sensors were sent all over the world with the objective of mapping out terrain to gather tree canopy height and biomass data; This data is in turn used to correlate vegetation with the global carbon cycle around the world.

Introduction

How much of the Earth's climate is affected by carbon emissions and how much climate change will impact vegetation? Questions such as those are answered through the use of radar and LiDAR remote sensing technologies. UAVSAR and LVIS are sent all over the world such as but not limited to, Canada, Colombia, Costa Rica, countries in Africa, and throughout the United States with the objective of mapping out the earth's terrain. By sending pulses of light to the earth from specific airborne heights, vegetation topography information as specific as its location on the earth corresponding to latitude and longitude coordinates, to the height of trees and other vegetation, including tree canopy length are achieved. Once vegetation data is sorted, the challenge arises in correlating all UAVSAR and LVIS data in order to validate them with each other and the actual objects. This is where I used the gathered data and attempted to find validation among the data sets by creating a program to run through thousands of lines of data and calculate the backscatter value of each latitude and longitude point from each data set. The backscatter data was then plotted against biomass and usually three different height metrics.

Goals and Purpose of The Project

UAVSAR works by using a polarimetric L-band synthetic aperture radar (SAR) that is able to transmit and receive airborne vertical (V) and horizontal (H) polarized radio waves. The SAR is mounted on the bottom of a Gulfstream G-III airplane to enable portability and efficacy as it gathers information around the earth. Additionally, SAR was designed to be fully operable on an autonomous airplane but it currently operates with a pilot and crew. The radar's antenna transmits and receives radio waves in only four ways. In transmit and receiving order, the four ways are HH, HV, VV, and VH polarizations, respectively. The antenna is able to do this using a process called repeat pass interferometry. The order in which the polarized waves are both sent and received are important when attempting to recreate color or black and white 3D images of the surveyed land.

Table 1. UAVSAR Transmitted and Received Signal Color Denotations

Polarized Signal Sent	Polarized Signal Received	Color Produced
H	H	Red
V	V	Green
H	V	Blue
V	H	None Noted

LVIS is also airborne, however, instead of radio waves it uses laser beams at the NIR spectrum range to measure the distance between the source of light and the desired targeted object. As the laser signal jumps back and forth from the source to the target, the signals create vectors that aid in the calculation of ground points or pixels of an image. LVIS makes use of a GPS and Inertial Navigation System (INS) that enables it to return location data in terms of latitude and longitude. My project was to search for relationships between radar parameters and estimates of canopy height from LVIS for Laurentides- a region in Quebec, Canada. By developing algorithms in C++ and Python, hundreds of thousands of lines of LIDAR topographical data were processed and graphed to check for latitude and longitude matches in reference to pixel equivalence of the actual LVIS picture. This was done in order to correlate and validate radar and LVIS backscatter data with biomass and tree height. For the particular data sets I worked with, the valid ranges of data were -20 to +2 dB and -50 to -1 dB for backscatter, and between 2 and 100 m for height values. Anything out of those ranges were cut out of the data sets.

Furthermore, neither a UAVSAR point nor an LVIS point is equivalent to a pixel point in a picture. A point of UAVSAR and LVIS data actually encompasses a few pixels long and wide. To account for this discrepancy I also developed an algorithm to be able to average out values in box form surrounding a chosen data point. This effort would further compress the data and allow us to achieve a more accurate correlation among respective Laurentide sets.

Impact of The MUST Internship On My Career Goals

Working with my JPL NASA mentor, Dr. Simard, has further affirmed my belief that anything is possible if you only dare to try. He was patient, diligent, and caring when it came to helping me achieve my ends. I came in having a basic knowledge of high-level computer programming but after working with him and his team, I can now call myself an intermediate programmer. He was always quick to respond and aid when I had a question

What I also liked about working with Dr. Simard is that he gave me deadlines for each section of the project because if he had not I probably would not have asked as many questions as I did because I would have tried to research it on my own – that could have taken the entire summer. Dr. Simard's team, in particular Bryan Riel, Sarah Flores, and Brian Hawkins, were of great help as well. Working with them made me realize that working at JPL is definitely a team effort and we all need each other's expertise and knowledge at some point. They were patient and quick to address my questions as well.

Working with other MUST scholar colleagues has only been inspiring. We are all high achievers and doing a lot from where we come from that it is impossible not to go home driven to do more academically and in the extracurricular sense.

Personally, this internship has impacted my goals in such a way that I know that I need to adjust certain priorities in life to be able maintain healthy when I am ready to join the full-time work train. In terms of my educational goals, this internship has made solid my decision to attend graduate school at some point after I finish my undergraduate studies. It has also pushed me to want to improve my GPA because, even though GPA is not always the most important determinant in the job applicant selection, it can open or close certain doors when it comes to graduate school. Professionally, this summer's internship has made me realize that I love working for NASA and would love to continue to do so when I graduate. It has also, however, made me realize that before I make such a decision I would like to see what working in private industry is also like. For the time being, I know I would definitely enjoy working for NASA after graduation because we do things that no other organization that is not affiliated to NASA, does.

Acknowledgements

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