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Estimation of Forest Biomass and Canopy Height using Passive Optical Remote Sensing and Radar with limited LiDAR Data

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1 Extended Abstract

Satellite and airplane-based remote sensing instruments are in use across the globe by both government entities and private corporations for purposes as diverse as military applications and environmental monitoring. Each new sensor enhances our collective ability to monitor the Earth both in terms of of what we are able to observe and the accuracy with which we can observe. One of the Earth's main systems, the carbon cycle, is of particular interest given its role in the global climate. The National Research Council 2007 decadal survey identified a significant gap in our understanding of the global carbon cycle [1] focusing on carbon fluxes in forests. A key component of the global carbon cycle is that of the role of forests in capturing carbon dioxide, a greenhouse gas, and in releasing carbon into soil and groundwater. Nearly half of a forest's aboveground biomass is carbon. Both understanding carbon fluxes in forests and mapping its variation over geographic areas and over time are key to improving our knowledge of this cycle at the local and global scale.

This paper presents a multi-modal remote sensing approach to accurately estimate forest parameters including mean canopy height and aboveground dry biomass with a focus on the BOREAS Southern Study Area (SSA). Polarimetric radar, LiDAR, and near-IR passive optical sensing platforms are employed in conjunction with physics-based models. It is shown that the proposed method is capable of achieving high accuracy estimates over large forest regions which contain minimal LiDAR measurements while using minimal ancillary data in the estimation process. Each of these remote sensor types has been employed in our study site, the BOREAS Southern Study Area (SSA) in Saskatchewan, Canada and are readily available. Collected data include Landsat5 Thematic Mapper (TM) passive optical measurements, AirSAR L-, and C-band polarimetric radar backscatter measurements, and SLICER LiDAR airborne measurements and nearly all were collected between 1994 and 1996 [2]. This time range also includes a number of ground truth data-collections.

We have previously presented a method wherein multi-modal remote sensing is used to achieve accurate simultaneous estimates of a homogeneous forest stand's height and biomass [3]. This method requires the colocation of passive optical (Landsat5 TM) measurements along with L-band Synthetic Aperture Radar (SAR) and Light Detection and Ranging (LiDAR) measurements. We present a method to combine measured datasets with our geometric and electromagnetic sensor models to first estimate certain parameters that a LiDAR instrument would observe, if present, and then to use these estimated LiDAR parameters in conjunction with measured SAR and passive optical measurements to calibrate a forest parameter estimation algorithm. The proposed method yields an accurate estimate of forest structure including aboveground dry biomass and mean forest canopy height with RMS errors of 3.68 $\mathrm{kg/m^2}$ and 1.59 m respectively across twenty two homogeneous forest stands each lacking LiDAR measurements.

References

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