Jialong Duanmu

Multi-scale based forest biomass estimation using LiDAR data[1]

Forest biomass acts as an important indicator of carbon resources in terrestrial system. Estimation of forest biomass enables a straightforward measurement of carbon storage and provides initial values for process-based carbon cycle models to simulate carbon dynamics. Recently, LiDAR (Light Detection and Ranging) remote sensing, as a surveying technology measuring distance by illuminating a target with laser light, is increasingly used to estimate forest biomass because of its ability to detect the structure of forest. However, it is still not adequately studied from a viewpoint of multi-scale.

Multi-scale studies aim at analyzing the relationship between data in different resolution and/or different extent. Multi-scale transform includes downscaling and upscaling. Downscaling is to push down the scale from coarser spatial and temporal resolution into more detailed information with finer spatial and temporal resolution while upscaling is just the opposite. For forest biomass estimation based on LiDAR data, most of the researches from a viewpoint of multi-scale are about extent. However, the multi-scale based research about resolution is rarely attempted.

This study is an attempt for the application of multi-scale theory in forest aboveground biomass (AGB) estimation based on low density LiDAR data (less than 1 point/m^2). The study area is located in Krycklan catchment which is approximately 50 km northwest of Umeå, Sweden. A method based on local maximum height point identification and downscaling calibration is provided. By implementing local maximum elevation extraction and visualization of aerial images, an algorithm directly based on point cloud data is designed. This algorithm retains more details of the LiDAR data and therefore provides better results. Two calibration look-up tables are founded from a viewpoint of downscaling. By inferring the result extracted from high density LiDAR data (more than 1 point/m^2) with low density LiDAR data, the forest parameter estimation accuracy based on low density LiDAR data is improved.

The error of downscaling calibration in the test sample plot is of 0.28%, which proved validity of the method applied. Furthermore, the calibration look-up tables can be used directly in the further researches of the study area in the same situation.

Key words: Physical Geography and Ecosystem Analysis, LiDAR, remote sensing, aboveground biomass (AGB), multi-scale, downscaling, individual tree identification

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[1] The original title of the thesis is "A multi-scale based method for estimating coniferous forest aboveground biomass using low density airborne LiDAR data"