Snow pack modeling using LiDAR derived elevation data

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In this research snow pack modeling was attempted in the Elbow River watershed west of Calgary, Alberta, using LiDAR-derived elevation data. The City of Calgary and the Department of Sustainable Resources Development (SRD) were interested in determining whether a winter and summer LiDAR dataset can be used to estimate the mean snow depth. LiDAR is an airborne laser system that calculates the distance to the ground by determining the return time of emitted laser pulses spatially located by a survey grade global positioning system (GPS) and an inertial motion unit (IMU). Subtraction (Digital Elevation Model (DEM) change detection) of the summer dataset from the winter dataset provides a snow depth dataset that is used to determine mean snow depth. Mean snow depth and average field-measured snow densities were used to calculate snow water equivalent (SWE). An estimate of snow volume was determined using three methods: (1) mean snow depth; (2) terrain attributes (slope, aspect, elevation, and canopy fractional cover) individually; and (3) a multiple terrain attribute GIS approach. Application of an average snow depth ($3.4 \times 10^7 m^3$) rendered a similar approximate value for snow water equivalent for the study site as the results from slope ($3.6 \times 10^7 m^3$), aspect ($3.5 \times 10^7 m^3$) and canopy fractional cover ($3.5 \times 10^7 m^3$) terrain attributes. Elevation ($4.2 \times 10^7 m^3$) and the GIS model ($4.3 \times 10^7 m^3$) gave higher estimates of snow water equivalent in the Elbow River watershed as elevation plays a strong role in snow accumulation.

Preliminary results indicate that the use of LiDAR to estimate snow depth is a viable option for the determination of snow depth in a mountainous region. Future research will include validation of LiDAR runoff values with stream gauge data. As well, these methods will be re-evaluated in an area of greater snow depth (the average snow depth in the Elbow River watershed was 18 cm, which is the accuracy limit of current LiDAR systems). The results of this study indicate that this research can be used in conjunction with current water resource management strategies to assist in prediction of seasonal runoff volumes. More accurate watershed water volume prediction strategies can aid city planners with regulating water supply as well as preparing for flooding events.

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