Vegetation Bias Correction in Tidal Salt Marsh LiDAR Data Sets with Artificial Neural Networks

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Objectives
Accurate ground elevation is critical for assessing the health and stability of coastal salt marshes and for hydrodynamic modeling of wetland circulation patterns. Elevation of the marsh platform is used for mapping of potential inundation from relative sea-level rise, calculation of sediment deposition and accretion rates, vegetative species identification, and assessments of flood risk from coastal storms. Errors of a few centimeters in vertical elevation could cause inaccuracies that subsequently lead to biased evaluation of risk mapping, marsh productivity, flooding and draining behavior, and morphodynamics. In the present work, we have implemented a new methodology to decrease the LiDAR vertical bias of the bare-earth surface in a coastal salt marsh using Artificial Neural Networks (ANN), within Bombay Hook Wildlife Refuge located along the western shore of Delaware Bay, DE [Fig.1 (Left)]. Fig.2 shows raw LiDAR topographic data acquired by USGS in 2014 and bathymetric data collected in 2015 (Box B).

Introduction
Light Detection and Ranging (LiDAR) is a popular and advanced growing technology for observing vertical elevations with high spatial and vertical accuracy for large areas very quickly [Fig2]. The high vertical accuracy of LiDAR data sets to calculate the bare-earth ground surface has been proved for unvegetated areas. However, in highly vegetated areas like tidal marshlands, the vertical bias of the bare-earth surface increases due to the inability of LiDAR to reliably penetrate dense vegetation canopies [Fig.1 (A) & Fig.4 (Left)].

LiDAR Data Acquisition

Data sets include vegetation maps provided by the US Fish and Wildlife Service (FWS) and National Wetlands Inventory (NWI), LiDAR intensity from a 2014 LiDAR acquisition project from USGS, and multiple DEMs, each derived from high-quality LiDAR collected at Quality Level 2 or better. We have trained, validated and tested the performance of the ANN using an extensive surveyed dataset collected over marsh platform. Ground truth is provided by a set of RTK survey points collected at numerous locations over the marsh platform, covering a variety of dominant vegetation types including Spartina patens, Spartina alterniflora, Spartina cynosuroides Scirpus robustus, Phragmites australis, Iva frutescens and Distichlis spicata. The data set includes 1484 points over the saltwater marsh and in a fresh water impoundment [Fig.1 (Right)].

Artificial Neural Networks

The ANN approach seems to be a suitable candidate to address problems where the relationships among variables are complex (not linear). The behavior of an ANN is defined based on a training rule and determine the connection between variables by allocating weight (w_i) and bias (b_j) to each function [Fig3].

Analysis & Results

The ANN in this study is trained by existing vegetation maps, LiDAR intensity distribution, and multiple LiDAR digital elevation models (DEM) acquired for Bombay Hook NWR area on three separate occasions: topographic LiDAR in spring 2011 by the Delaware Dept. of Nat. Resources and Env. Control (DNREC), topographic LiDAR in winter 2014 by USGS, and topo-bathymetric LiDAR by NOAA NGS also in winter 2014. Other input variables in the ANN include vegetation maps provided by the US Fish and Wildlife Service (FWS) and National Wetlands Inventory (NWI), LiDAR intensity from a 2014 LiDAR acquisition project from USGS, and multiple DEMs, each derived from high-quality LiDAR collected at Quality Level 2 or better. We have trained, validated and tested the performance of the ANN using an extensive surveyed dataset collected over marsh platform. Ground truth is provided by a set of RTK survey points collected at numerous locations over the marsh platform, covering a variety of dominant vegetation types including Spartina patens, Spartina alterniflora, Spartina cynosuroides Scirpus robustus, Phragmites australis, Iva frutescens and Distichlis spicata. The data set includes 1484 points over the saltwater marsh and in a fresh water impoundment [Fig.1 (Right)].

For hydrodynamic study, see poster Abdolali et al. 2016, “Field and modeling studies of salt marshes in Bombay Hook National Wildlife Refuge in Delaware”.

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