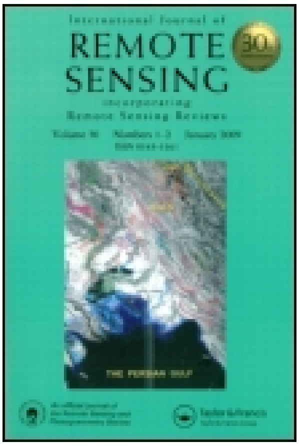

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Cover: Use of LIDAR elevation data to construct a high-resolution digital terrain model for an estuarine marsh area

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Cover

Use of LIDAR elevation data to construct a high-resolution digital terrain model for an estuarine marsh area

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1. Introduction

Because of their high environmental and ecological value, estuarine marshes have been a focus for numerous interdisciplinary efforts to discover patterns, relationships and models to lead to successful management and sustainable use of the resources (Hobbie 2000). However, these efforts may be hindered because of the lack of adequate topographical data over estuarine tidal areas (Populus *et al.* 2001). Most of the currently available digital elevation datasets, such as GTOPO30, the US Geological Survey's digital elevation models (USGS DEMs) and the National Aeronautics & Space Administration (NASA) Shuttle Radar Topography Mission (SRTM), are basically useless for estuarine marsh areas where the terrain is featureless and of limited contrast. Thus, there is a strong need to develop high-resolution elevation datasets for these environmentally sensitive areas.

This article reports research aiming to build a high-resolution digital terrain elevation model for part of the North Inlet estuary in Georgetown, South Carolina, USA (figure 1) by using airborne LIDAR (Light Detection and Ranging) data. This

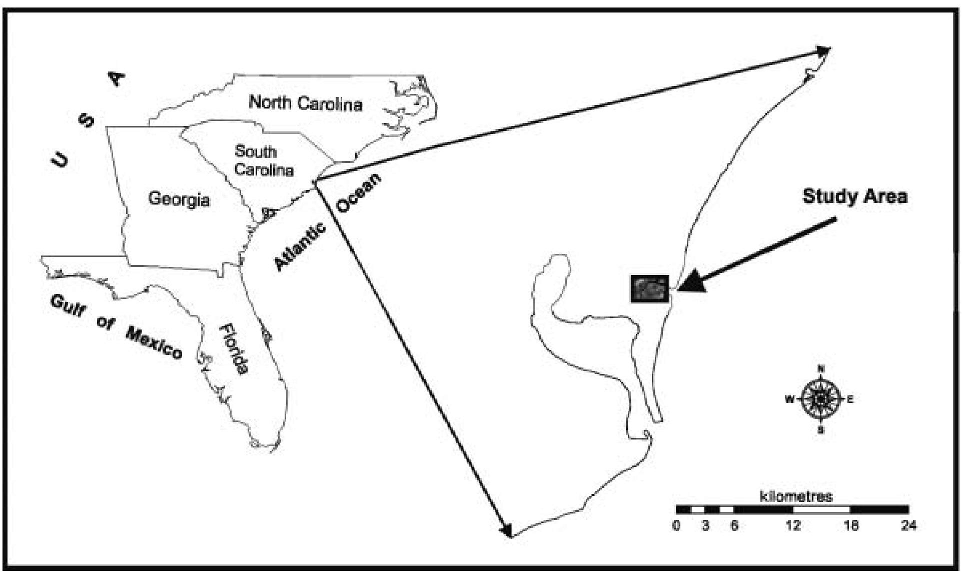

Figure 1. Location of the study area, along the Atlantic coast of South Carolina, USA. The study site covers an area of $6.16\,km^2$.

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has been part of an interdisciplinary effort to investigate the relationship between stream order, water quality and natural influences in the North Inlet estuary. High-resolution digital elevation data are needed for Geographical Information System (GIS)-based hydrological network modelling to delineate hydrographical features and to determine stream orders. LIDAR technology has already demonstrated its capability to produce digital terrain models with sub-metre vertical and horizontal resolutions (Populus *et al.* 2001, Hodgson *et al.* 2003, Lowe 2003). Therefore, LIDAR data should be well suited to estuarine marsh elevation mapping.

2. Methodology

The study site is located along the Atlantic coast, covering an area of approximately 6 km^2. It consists mainly of salt marshes behind barrier islands, along with numerous tidal creeks (figure 2). These creeks receive large volumes of ocean water that flow into and out of the marsh twice daily (NOAA 2004). The terrain is underlain by a complex sequence of older coastal plain sediments. Most of the study area is less than 3 feet above sea level.

The LIDAR data were collected by Airborne1, Inc., using an Optech Airborne Lasar Terrain Mapper (ALTM) 2025 sensor on 16 January 2003 (Morris *et al.* 2005). The entire dataset was processed by using vegetation removal algorithms to create a bare-earth model. The nominal posting density ranges from 1.5 m to 5 m. The LIDAR elevation dataset contains a total of 1 247 819 points. Each point has a record of horizontal coordinates and elevation. The dataset was organized in ASCII format. It was georeferenced to the Universal Transverse Mercator (UTM) map projection (Zone 17), WGS84 horizontal datum and WGS84 ellipsoid.

A TIN (Triangulated Irregular Networks) model was created from the LIDAR elevation points by using the Delaunay triangulation method (Zeiler 1999). The TIN surface model consists of 2 495 221 irregular triangles, 1 247 653 nodes and 7 485 663

Figure 2. Photograph showing part of the North Inlet estuary, Georgetown, South Carolina, USA. The site consists of a large area of salt marsh (in green) and numerous tidal creeks. Photograph taken on 13 August 2003 by Luoheng Han at the University of Alabama.

edges, which demands a great deal of computational resources even for a 3D drawing operation. To improve the computational speed, the TIN model was converted into a grid-based surface model with 1 m cell size. An accuracy assessment was conducted by using a random sample of 1024 points through a cross-validation method. The model was found to have a global rms. error of 0.164 foot. Figure 3 is a three-dimensional perspective view of this grid model with a vertical exaggeration of 25 times to portray the terrain relief more effectively.

A high-resolution multi-spectral image acquired by an ADAR (Airborne Data Acquisition and Registration) 5500 digital camera system in October 2000 (Morris *et al.* 2005) was used for the validation of terrain features derived from the aforementioned DEM. The ADAR image has a nominal spatial resolution of 0.7 m and consists of four bands – blue (450–540 nm), green (520–605 nm), red (610–690 nm) and near-infrared (750–860 nm). Figure 4 (and on cover) is a three-dimensional perspective view of the digital terrain elevation model draped with the false-colour ADAR image.

3. Results and further research

The DEM, given its very high spatial resolution and tiny rms. error, allows the differentiation of many delicate terrain features, particularly various micro-landforms and tidal creeks, which can be visualized clearly from figure 3. These subtle landform features portrayed by the LIDAR-derived DEM are found to be highly faithful to reality when using the high-resolution ADAR image as a reference (see figure 4). Note that the image colour changes in different micro-landform units and where terrain elevation fluctuates.

Further research efforts are being made to use this DEM for hydrological network modelling to delineate hydrographical features. This will challenge the existing hydrological modelling technologies which were basically developed for areas with large terrain relief.

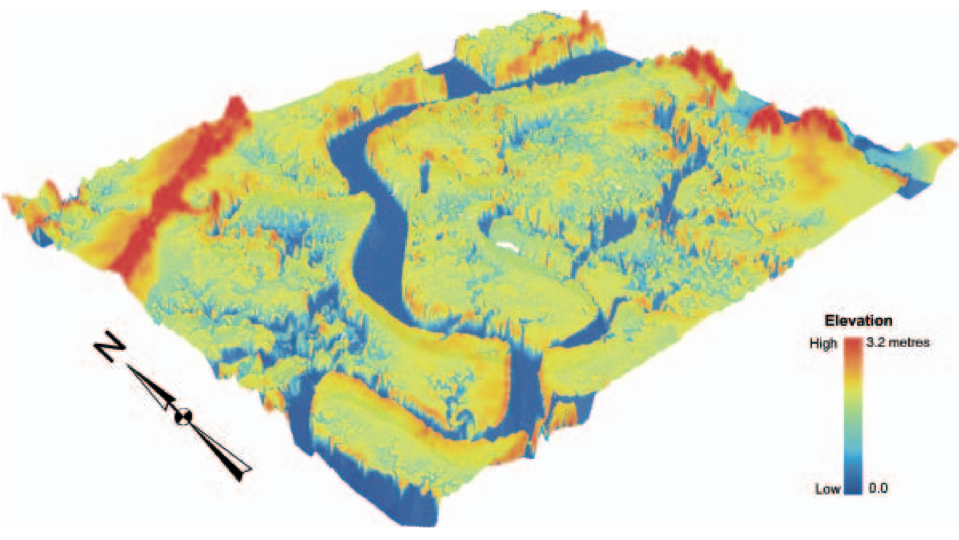

Figure 3. A three-dimensional perspective view of the digital terrain elevation model created using Delaunay triangulation from LIDAR elevation data. The model covers a ground area of approximately 2180 m by 2760 m. Note that the vertical scale has been exaggerated 25 times to portray the terrain relief more effectively.

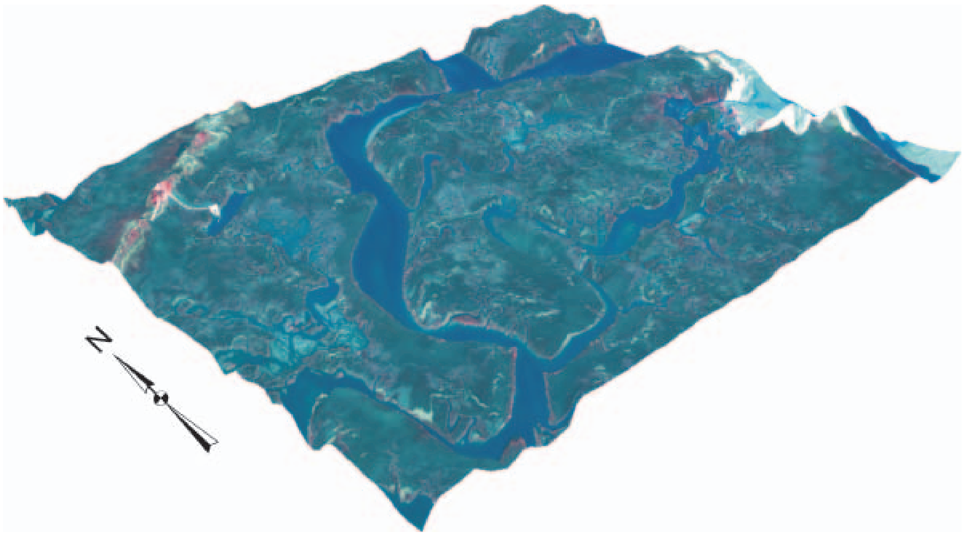

Figure 4. A three-dimensional perspective view of the digital terrain elevation model draped with a false-colour ADAR image. The model covers a ground area of approximately 2180 m by 2760 m. Note that the vertical scale has been exaggerated 25 times to portray the terrain relief more effectively.

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