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Land-cover class as a qualifier for quoted elevation error in aerial LiDAR.

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Introduction

LiDAR derived Digital Elevation data are used widely in the Geosciences to model topographically dependent environmental processes. High accuracies are not required for all applications, but modelling elevation sensitive processes such as flood or erosion risk generally requires data that accurately represent the ground surface. LiDAR Digital Surface Model (DSM) data do provide very high accuracies relative to many other classes of Digital Elevation Model (DEM). However, even LiDAR is subject to some error, and quite significant elevation errors can occur whenever dense ground vegetation cover interferes with laser illumination of a bare ground surface (Flood, 2004).

Bare-earth LiDAR DEMs generated by reference to first and last laser returns (Lim et al., 2003, Hall et al., 2005; Webster, 2006) and from full waveform digitisation (Nayegandhi et al., 2006, Wagner et al., 2008) do facilitate the removal of much of the error that derives from the presence of vegetation. However, the efficiency of these methods tends to be reduced in densely vegetated areas (Flood, 2004). As a consequence of this, quoted LiDAR error may fail to account for actual error in all cases in natural areas (Hodgson and Bresnahan, 2004). This may be particularly problematic of the data are to be used to model elevation-sensitive environmental processes such as flood risk.

The accuracy of three spatially-coincident aerial LiDAR datasets is examined in a low-lying coastal area (figure 2b) to clarify the relationship between generic land cover classes and LiDAR elevation error. Ground validation data are captured using FastStatic and RTK GPS data capture. The number of validation points used, the GPS survey methods employed, and the land-cover classes (table 1) assessed are designed to surpass the minimum requirements of the American Society of Photogrammetry and Remote Sensing (ASPRS) guidelines for the validation of LIDAR error (Flood, 2004).

Generic class	Land cover type
Natural	Open terrain (sand, rock, soil, ploughed fields, lawns, golf courses).
Natural	Brush lands and low trees.
Natural / semi-natural	Tall weeds and crops.
Semi-natural	Forested areas fully covered by trees.
Anthropogenic	Urban areas with dense man-made structures.

Table 1. Land-cover classes evaluated (source ASPRS, 2004).

Three aerial LiDAR datasets are used in the study. These include the onshore component of the INFOMAR (Integrated Mapping For the Sustainable Development of Ireland's Marine Resource) bathymetric LiDAR dataset, the Office of Public Works (OPW) coastal management LiDAR dataset and the Ordnance Survey Ireland (OSI) bare-earth LiDAR DEM dataset (figure 1).

Methods

Absolute elevation error is quantified for each dataset in idealised control areas prior to assessing the influence of ground vegetation in order to isolate LiDAR measurement error from residual ground vegetation error. LiDAR measurement error is determined using FastStatic GPS in open paved areas residual vegetation error is measured using a combination of FastStatic GPS (for urban and forested areas) and RTK GPS in Open terrain, Brush lands and cropland / weeded areas.

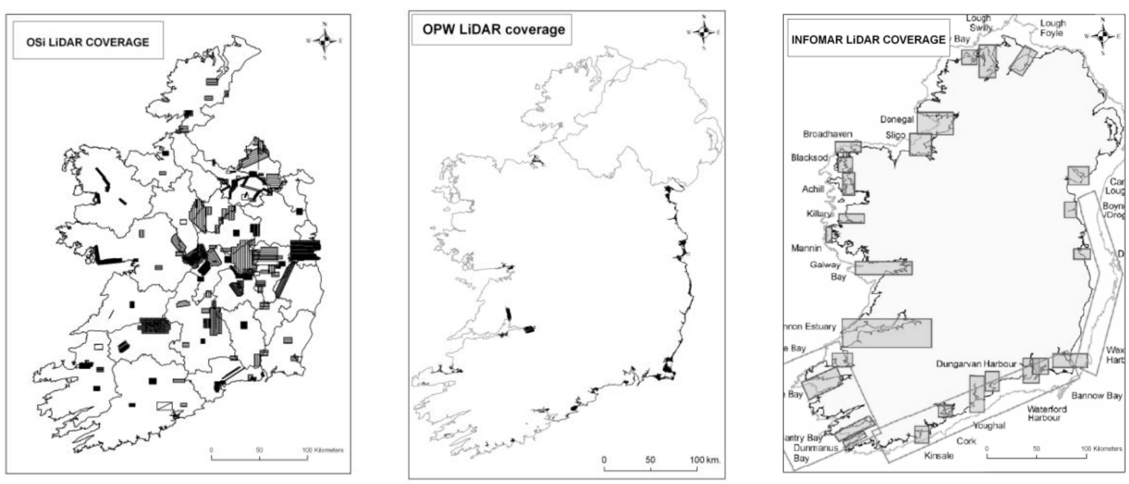

Figure 1. OSi, OPW and INFOMAR LiDAR Coverages for Ireland

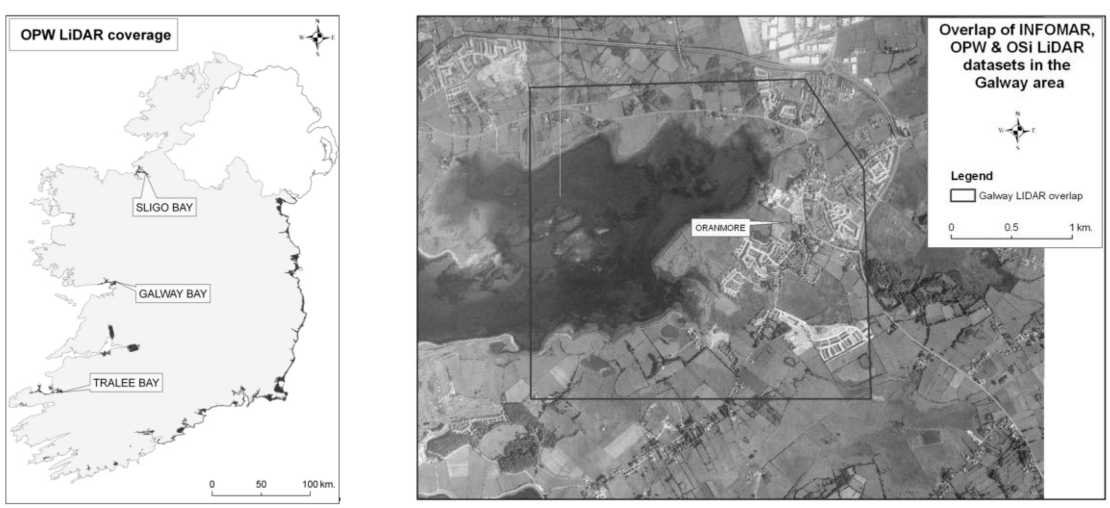

Figure 2(a) Three LiDAR overlap areas and (b) optimal overlap area

Three potential study areas are considered where all three LIDAR datasets overlap (figure 2a) and an area in the vicinity of Oranmore town (figure 2b) in Galway bay is selected due to the large overlap of all three datasets and the variable land cover present in the area. Data validation is carried out using ArcInfo Geostatistical Analyst, generating 2.5D kriging prediction surfaces for each LiDAR dataset, and using the GPS data to validate data error in the five land cover classes tested.

Discussion

LiDAR measurement error is found to be broadly in agreement with the statistics provided by data suppliers in all cases, confirming the reliability of each dataset in non-vegetated areas. However, the magnitude of the errors associated with the presence or absence of vegetation in each of the landcover classes tested are found to vary in relation to vegetation canopy density and depth. Errors substantially larger than the global errors quoted by data suppliers were found in all three LiDAR datasets, highlighting the difficulties that may arise when LiDAR data are used to model elevation sensitive processes (such as coastal flood risk) in natural areas.

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