International Journal of REMOTE SENSING Volume 31 Number 5 10 March 2010

International Journal of

REMOTE SENSING

incorporating

Remote Sensing Reviews

Volume 31 Number 5 10 March 2010

ISSN 0143–1161

Special Issue: SilviLaser 2008

Guest Editors: Ross Hill and Juan Suárez

Rapid Communications now in *Remote Sensing Letters*

REMOTE SENSING AND PHOTOGRAMMETRY SOCIETY

An official journal of the Remote Sensing and Photogrammetry Society

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Special Issue – SilviLaser 2008

Papers based on presentations made at the 8th International Conference on LiDAR Applications in Forest Assessment and Inventory, held in Edinburgh, Scotland, UK, 17-19 September 2008

Guest Editors

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Juan Suárez

International Journal of Remote Sensing
Vol. 31, No. 5, 10 March 2010, 1129–1132

Taylor & Francis
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Preface

SilviLaser: applications of laser systems for forest assessment and inventory

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In recent years, there has been rapid development and uptake of laser systems operating on a principal of Light Detection And Ranging (LiDAR) in the inventory, assessment and monitoring of forests. Applications of laser technology have included the estimation of forest biophysical parameters (including carbon) at the individual tree or stand level as part of local, regional and even national forest inventory. In addition, laser data have been used to monitor forest change, model susceptibility to wind or fire damage and map wildlife habitat. Laser systems can operate on ground-based, airborne and satellite platforms. They are typically categorised as profiling or scanning systems, and as supplying range and intensity data for discrete returns or full waveform information per laser pulse.

SilviLaser 2008 (http://www.forestresearch.gov.uk/Silvilaser2008) was the eighth in a series of international conferences focusing on applications of laser systems for forest assessment and inventory. In September 2008, this well-established conference was brought to the UK. Previous conferences took place in Canada, Australia, Sweden, Germany, USA, Japan and Finland.

The aim of SilviLaser 2008 was to bring together research scientists and forest practitioners from around the world to share their experience in the development and application of LiDAR for forest measurement. Presentations covered all forms of laser systems, from all possible platforms, and across a range of forest applications. The conference had six session themes: (1) forestry applications and inventory; (2) data fusion; (3) ecological applications and habitat mapping; (4) waveform LiDAR; (5) algorithm and techniques development; and (6) terrestrial laser scanning and laser cameras. The ecological session was sponsored by the British Ecological Society, whilst other conference sponsors included ESRI and 3D Laser Mapping. A technical workshop on terrestrial laser scanning took place the day before the conference and highlighted the growing interest of this technique for field-data collection.

SilviLaser 2008 attracted over 200 delegates from 21 different countries across five continents. This event provided an informed discussion forum on the state-of-the-art in laser applications in forestry that attracted the interest of scientists, commercial foresters and system developers. The two day event included 44 poster presentations and 38 oral presentations. Due to high demand, the acceptance criteria for oral presentations at SilviLaser 2008 were very selective. The conference encouraged new and stronger linkages between LiDAR practitioners, and, in particular, between researchers, data providers and end users of derived products.

The conference proceedings for SilviLaser 2008 (Hill *et al.* 2008) contain 68 full papers plus an additional 14 abstracts, all of which were double-blind reviewed by at least two experts in the field (http://geography.swan.ac.uk/silvilaser/).This Special Issue of the *International Journal of Remote Sensing* contains an invited

International Journal of Remote Sensing
ISSN 0143-1161 print/ISSN 1366-5901 online © 2010 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/01431160903380698

selection of these papers, which have been expanded and developed from their conference format.

There are now numerous reported studies on the application of LiDAR for large-area forest measurement and inventory. However, a key issue in the development of any empirical model linking LiDAR and field-inventory data is the accuracy of spatial co-registration between datasets. The paper by Dorigo *et al*. (2010) investigates a new automated co-registration approach that gives a best match between a LiDAR-derived Canopy Height Model and tree position and height data recorded as part of National Forest Inventory. This approach takes into account the tree selection criterion offered by angle-count sampling.

Having established a spatial match between airborne LiDAR and field inventory data, five papers in this Special Issue directly address methods of deriving key forestry measures and investigate the factors that influence their derivation. Rombouts *et al.* (2010) assess the relative influence of operational LiDAR collection parameters and site characteristics on prediction models for predominant height and stand volume, as input to site-quality assessment. Lindberg *et al.* (2010) present a new method of combining single tree and area-based methods for forest inventory in airborne LiDAR data. Their three-stage process attempts to overcome the frequently reported difficulty in individual tree-crown segmentation of detecting all trees, thereby eliminating the bias that typically results. Gaulton and Malthus (2010) introduce a new approach for the delineation of canopy gaps directly from point cloud data, thereby avoiding the need to interpolate a raster Canopy Height Model. Vauhkonen (2010) compares the use of Delaunay triangulation and alpha shapes with the analysis of return frequencies and linear regression to predict crown base height from airborne LiDAR data. The paper by Solberg (2010) investigates variables based on LiDAR echo counting and echo intensity to map gap fraction, leaf area index and disturbance (both by defoliation and cutting).

In addition to developing empirical models based on field data, LiDAR data can also be used to guide field data collection. In the paper by Pesonen *et al.* (2010), the application of LiDAR is demonstrated as auxiliary information to guide the sample-based field inventory of coarse woody debris. In particular, the use of LiDAR in the design phase of field sampling (by implementing probability proportional to size sampling) was shown to significantly increase sampling efficiency.

The integration of LiDAR with satellite multi-spectral data as a means of scaling up forest assessment is discussed in the papers by Pascual *et al*. (2010) and Takahashi *et al*. (2010). The former of these papers compares mean and median LiDAR height with the Normalised Difference Vegetation and Moisture Indices and with wetness Tasselled Cap derived from Landsat Enhanced Thematic Mapper Plus (ETM+). Takahashi *et al*. (2010) estimate stand volume for coniferous forests by combining airborne LiDAR data with QuickBird panchromatic imagery.

The above papers all make use of data acquired by an airborne, small-footprint, discrete return LiDAR system. These systems have traditionally supplied elevation information from the first and/or last return per laser pulse echo or from up to four returns per echo. However, the most recent commercial small-footprint systems can digitize the entire waveform, potentially enabling the user to decide on the most appropriate pulse detection technique to maximize the number of targets detected within complex waveforms. The paper by Lin *et al*. (2010) introduces a new method to do this (Rigorous Gaussian Detection) and compares this with two other pulse detection techniques available in commercial software.

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Three papers in this Special Issue investigate the use of satellite LiDAR data from the Ice, Cloud and land Elevation Satellite (ICESat) / Geoscience Laser Altimeter System (GLAS). Rosette *et al*. (2010) examine sources of uncertainty for the estimation of ground elevation and vegetation height from ICESat/GLAS data using airborne LiDAR data, field measurements and a radiative transfer model (FLIGHT). The paper by North *et al.* (2010) also makes use of the FLIGHT radiative transfer model to examine the relationships between the integrated LiDAR waveform energy and bidirectional reflectance factors derived from FLIGHT, and between simulated and observed ICESat/GLAS waveforms for a complex forest site. Finally, the paper by Nelson (2010) investigates four different multiple linear models to estimate aboveground dry forest biomass and carbon for the Province of Québec, Canada.

Together, these thirteen papers demonstrate a healthy balance between method development and forestry applications and with a cross-over demonstrated between the predominant focus on small-footprint, discrete-return data and waveform data. Future SilviLaser conferences are likely to see a greater emphasis on small-footprint waveform data and for national or regional scale forest inventory on space-borne systems such as the proposed ICESat II and Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI).

We wish to thank Professor Giles Foody for granting this Special Issue and to Mrs Catherine Murray for all of her kind assistance in handling the manuscripts. We are grateful to members of the SilviLaser Scientific Committee and review panel, who helped to select papers for this Special Issue. Finally, we are particularly grateful to all contributing authors and all reviewers of draft manuscripts, whose hard work has resulted in a high-quality set of papers that we are pleased to present for you.

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