Estimation of Canopy Height using UAVSAR Data in the Reserve Faunique des Laurentides and Penobscott Forests.

Marc Simard
Jet Propulsion Laboratory, California Institute of Technology

Marco Lavalle, Naiara Pinto, Scott Hensley, Maxim Neumman, Thierry Michel, Ralph Dubayah

JPL/Caltech Copyright 2012. All rights reserved
An Empirical Assessment of Temporal Decorrelation Using the Uninhabited Aerial Vehicle Synthetic Aperture Radar over Forested Landscapes

Marc Simard 1*, Scott Hensley 1, Marco Lavalle 1, Ralph Dubayah 2, Naiara Pinto 2 and Michelle Hofton 2

Figure 5. Variation of temporal coherence $\gamma_t$ with canopy height. (a) HH coherence for mixed temperate and boreal coniferous forests at various time intervals and two time periods. The vertical bars in (b) give the standard deviations for discrete height intervals and are not shown in (a) for clarity.
A Temporal Decorrelation Model for Polarimetric Radar Interferometers

Marco Lavalle, Marc Simard, and Scott Hensley

Fig. 2. Structure functions and motion variance of a canopy layer with underlying ground surface. The structure function of the RV model and of the RVoG model corresponds to (11) and (15). The motion variance illustrates the function in (9). The structure functions and the motion variance are used to derive the temporal coherence model in Section III.
**Figure 8.** Actual and modeled patch age from UAVSAR coherence data with zero spatial baseline and 2-day temporal baseline.

\[ R^2 = 0.7 \text{ and RMS} \approx 5.5 \text{ depending on scale} \]
Mapping Migratory Bird Prevalence Using Remote Sensing Data Fusion

Anu Swatantran¹, Ralph Dubayah¹, Scott Goetz², Michelle Hofton³, Matthew G. Betts⁴, Mindy Sun⁵
Dartmouth College, Hanover, New Hampshire, United States of America

Abstract

Improved maps of species distributions are important for effective management of wildlife under increasing anthropogenic pressures. Recent advances in lidar and radar remote sensing have shown considerable potential for mapping forest structure and habitat characteristics across landscapes. However, their relative efficacies and integrated use remain largely unexplored.

Methodology and Principal Findings:

We tested multispecies models using observations from the Harvard Forest Breeding Bird Monitoring program, lidar, and multitemporal multispectral data. A novel approach utilizing a multi-dimensional habitat structure was developed that integrates lidar and radar snow and vegetation variables to produce multi-dimensional habitat structure maps at landscape scales. These maps accurately predicted species prevalence across a range of forest structures.

Figure 8. Quantile predictions for black-throated blue warbler [BTBW] and magnolia warbler [MAWA].

doi:10.1371/journal.pone.0028922.g008
Achieving accuracy requirements for forest biomass mapping: A spaceborne data fusion method for estimating forest biomass and LiDAR sampling error

P.M. Montesano a,b,c,*, B.D. Cook b, G. Sun c, M. Simard d, R.F. Nelson b, K.J. Ranson b, Z. Zhang c, S. Luthcke b

Algorithms, where accuracy is not within estimates are within ±10% of the greater of the two, for at least 80% of grid cells. A data fusion approach also provides a means to extend those associated with LiDAR footprint sampling over regional spatial variation of forest AGB, and help improve monitoring of carbon balances, where minimum sampling errors were 11, 15, 18, and 22 Mg ha$^{-1}$ for 1 km, 500 m, 250 m, and 100 m grid scales, respectively.

1. Introduction

Spatially explicit estimates of the vertical dimension of forests are critical terms, sampling errors were reduced from 14 to 11 Mg ha$^{-1}$ – 28 Mg ha$^{-1}$ for 1 km, 250 m, and 100 m grid scales, respectively.

2. A data fusion approach for estimating AGB using simulated spaceborne LiDAR with SAR and passive optical image combinations of passive optical, SAR and wall-to-wall LiDAR data. We used this image-derived data with simulated spaceborne LiDAR derived from orbit and 403 km scale from the corresponding data combination and prediction method.

3. At least 80% of the grid cells at 100 m, 250 m, 500 m, and 1 km grid levels meet the accuracy requirements that will provide detailed understanding of the global scale accuracy requirements were met at the 500 m and 250 m grid level, respectively.

4. Using either passive optical or SAR the spaceborne global scale accuracy requirements were applied to a range of spaceborne or airborne remote sensing measurements from future earth observation missions. Furthermore, these results can guide future campaigns near Howland, ME, USA, to assess AGB and LiDAR sampling errors of the two, for at least 80% of grid cells. A data fusion approach also provides a means to extend those associated with LiDAR footprint sampling over regional spatial variation of forest AGB, and help improve monitoring of carbon balances, where minimum sampling errors were 11, 15, 18, and 22 Mg ha$^{-1}$ for 1 km, 500 m, 250 m, and 100 m grid scales, respectively.

* Corresponding author at: Code 618, Biospheric Sciences Branch, NASA/Goddard Space Flight Center, Greenbelt, MD 20771, USA.

E-mail address: Paul.M.Montesano@nasa.gov (P.M. Montesano).
Global Map of Forest Canopy Height (1km resolution)

Simard, Pinto, Baccini and Fisher (Journal of Geophysical Research, 2011)

Marc.simard@jpl.nasa.gov
The project documents every instance of the phrase "is the new" encountered from various sources in 2005. It is intended to map the iterations of a peculiarly common marketing and literary device.

http://thediagram.com/6_3/leisurearts.html
UAVSAR Campaign 2009-2010

• PI: Marc Simard,
  – Co-I’s Ralph Dubayah, Scott Hensley
• Objective:
  – To assess, quantify and mitigate the impact of temporal decorrelation on the retrieval of canopy height from polinSAR
Airborne and Field Data Collection

**UAVSAR**
L-band polarimetric radar capable of repeat pass interferometry

**LVIS**
Laser Vegetation Imaging System
Full waveform lidar (25m footprint)

- **Spatial resolution**
  - UAVSAR: ~6m
  - LVIS: ~25m

- **Swaths**
  - UAVSAR: ~20km
  - LVIS: 2km (based on max of 5° look for vegetation)

- **Field data (88 forest plots)**
  - Tree height;
  - Trunk diameter DBH
  - Tree species
  - Crown size
  - Terrain Slopes
  - Plot height and biomass

Marc.simard@jpl.nasa.gov
Sites

- Laurentides, Québec
- Penobscott/Howland, Maine
- Bartlett/Hubbard Brook, New Hampshire
- Sierra Nevada, California
- La Selva, Costa Rica
UAVSAR Campaign 2009-2010

- Test Sites cover a wide range of forest types and terrain
  - New Hampshire (Temperate)
  - Maine (Temperate)
  - Québec (Temperate and boreal)
  - Sierra (Temperate with strong elevational gradient)
  - La Selva (Tropical)
Data collection strategy

- UAVSAR images covered transects of ~100km with ~20km swath (Laurentides is 185km long)
- Covered boreal, temperate and tropical forests
- Large diversity of management practices:
  - sites are characterized by experimental forests, national parks and managed forests (e.g. lumber)
- UAVSAR flew 3 days (5 in tropics) over a period of about 2 weeks.
  - Each day, UAVSAR flew 4 times over each site.
  - Collected both zero and 65m baselines.
- Example:
  - North East sites flown on 5th, 7th and 14th of August 2009.
  - Providing 4 temporal baselines of 45', 2, 7 and 9 days
  - Costa Rica: January 29th, 31st, February 4th, 6th, 10th 2010
  - Temporal baselines: 30' and 2, 4, 6, 9, 10 and 12 days
It is precipitation and change in moisture rather than “time” that most impacts temporal decorrelation on temporal scales of days.

- A large rain storm on the acquisition date of the 7\textsuperscript{th} causes a decrease of the inSAR correlation with pairs including other days.
- Wind is nearly stable between 5 and 10km/h.
Temporal Decorrelation Experiment
Summary and Conclusion

3D Land Mapping
Combining Lidar and Radar for Remote Sensing of Land Surfaces

Click on a marker to find out more information about your favorite site.

Site: Laurentides Wildlife Reserve (Super Site)
Country: Quebec

View site Data

Project Description
This website presents the research projects of Dr. Marc Simard, Senior Scientist at the Jet Propulsion Laboratory. The overall objective is to combine radar and lidar remote sensing to characterize the forested landscapes in 3D. The science products generated by Simard and
Super Site: Laurentides Wildlife Reserve, Quebec

Click a checkbox to show a specific dataset in the map. Then click the objects (markers, swaths, etc) in the map for more information.

- Super Site [KML]
- UAVSAR
- LVIS
- ICESat [TXT]
- SRTM [KMZ]
- Field Data [CSV]
- Weather Data [KML]

UAVSAR Swath Details: Laurnt_00802

Radiometrically Calibrated Backscatter  (View a high-resolution map here)

- Low-resolution: [KML], GeoTIFF files by polarization: [HH] [HV] [VV]
A Cal/Val Super Site for Active Remote Sensing Platforms

Réserve Faunique des Laurentides (Québec, Canada) proposed at CEOS 2010

- Laurentides
  - 1000m elevation range
  - Temperate and boreal forests
  - National Parks
  - Experimental forests
  - Large scale (Governmental) lumber management
  - Public access to all sites

- Data
  - UAVSAR, ALOS/PALSAR
  - repeat-pass UAVSAR (Multi-temporal)
  - MODIS, LANDSAT
  - Lidars : LVIS, ICESat/GLAS, high res.
  - TanDEM-X
  - Field
    - Canopy structure
    - Weather data
    - Government/industry participation
    - Stand age
  - Real Time Weather data
  - Accurate knowledge of terrain slope

- Missing
  - Radarsat (requested)
  - ENVISAT
  - TerraSAR-X
Penobscott, Maine
Laurentides, Québec
PolinSAR inversion of canopy Height
UAVSAR polinSAR vs Field Height
UAVSAR polinSAR vs Field Height
UAVSAR polinSAR vs Field Height

- $K_z < 0.2$
IS THE NEW
LeisureArts
The project documents every instance of the phrase "is the new" encountered from various sources in 2005. It is intended to map the iterations of a peculiarly common marketing and literary device.
http://thedigram.com/6_3/leisurearts.html
UAVSAR mangrove monitoring campaign in Central and South America

Térraba-Sierpe, Costa Rica
Gulf of Fonseca, Honduras
Chocó, Colombia
Guayas, Ecuador
Mangrove Vulnerability Assessment to Climate Change and Socio-Economic Pressure.
Time-series analysis with JAXA’s ALOS/PALSAR dataset (K&C initiative and Mangrove Watch)

- Launched in 2006, worked until April 2011
- Programmed for repeat data acquisition over global wetland sites through the Kyoto and Carbon Initiative in support of the Ramsar convention.
- Current research on using ALOS/PALSAR for mapping of land cover, degradation and biomass in mangroves

Collaborators: Souza-Filho, Nascimento, Lucas, Fatoyinbo
Conclusion

• We empirically estimated the impact of temporal decorrelation on interferometric coherence and identified a few causes
• We successfully performed polinSAR inversion of canopy height using repeat-pass UAVSAR data
• Future: Continue analysis of the impact of Kz, extinction, temporal decorrelation and spatial resolution
• Process other sites