

## METADATA FOR NASA GODDARD'S LIDAR, HYPERSPECTRAL AND THERMAL (G-LiHT) AIRBORNE IMAGER

### CONTENTS

- 1) Contact information
- 2) Campaign description
- 3) Flight plans
- 4) Acquisition details
- 5) Field observations
- 6) Output file name(s)
- 7) Data products
- 8) Instrument specifications
- 9) Publications

#### 1) CONTACT INFORMATION

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#### 2) CAMPAIGN INFORMATION

Date(s): 5 October 2011  
Time of day: 9:30 to 11 AM  
Location: Smithsonian Environment Research Center (SERC), near Edgewater, MD  
Description: SERC Leaf-on acquisition  
Research project: DART-LiDAR  
Funding source: NASA, Remote Sensing Theory

#### 3) FLIGHT PLANS

Series of N-S and E-W lines with ~30% swath overlap to 1) obtain high density, multi-angle lidar returns over stem mapped area; and 2) capture hot/cold spots with passive optical instrument.

#### 4) ACQUISITION DETAILS

Aircraft: NASA LaRC Cessna 206 with wing-mounted pod  
Pilot: Rick Yaskey, NASA LaRC  
G-LiHT operator(s): Larry Corp, NASA GSFC  
Nominal altitude (AGL): 335 m AGL  
Nominal velocity: 110-150 kt  
Other:

#### 5) FIELD OBSERVATIONS

Weather: Clear Sky Conditions  
Other notes:

#### 6) OUTPUT FILE NAME(S)

SERC\_Oct2011

#### 7) DATA PRODUCTS

##### GPS-INS

Trajectory: Aircraft location and orientation (roll, pitch, yaw). Available as 3D Google Earth overlay (KML) and 250 Hz data product (ASCII).

##### LiDAR

Canopy Height Model: Lidar-derived maximum canopy height (m AGL) and canopy rugosity (i.e., standard deviation of heights within an area equivalent to a 1/24 ac USFS-FIA subplot). Available as Google Earth overlay (KML) and raster data product (GeoTIFF) at a nominal 1 m spatial resolution.

Digital Terrain Model: Lidar-derived bare earth elevation (m, EGM96 geoid), aspect and slope. Available as Google Earth overlay (KML) and raster data product (GeoTIFF) at a nominal 1 m spatial resolution.

Lidar Apparent Reflectance: Mean reflectance for all, single returns from a 1550 nm laser. The lidar is factory calibrated and data corrected for ranging distance, but not scan angle or atmospheric interactions. Available as raster data product (GeoTIFF) at a nominal 1 m spatial resolution.

Lidar Point Cloud: Individual lidar return data, including 3D coordinates; classified ground returns ("Classification" field); AGL heights ("Point Source ID Text" field, using z scale factor and offsets); and lidar apparent reflectance ("Intensity" field; -25 to 0 dB for 2 byte range). Overlapping swaths are co-aligned with coincident ground returns to remove swath-to-swath elevation biases. Available in ASPRS LAS 1.1 format.

Lidar Metrics: Common lidar height, density, fractional cover and return statistics (e.g., mean pulse density, returns per pulse) for all returns +/- 30 degrees of nadir. Available as raster data product (GeoTIFF) at a nominal 13 m spatial resolution (area equivalent to a 1/24 ac USFS-FIA subplot).

#### Image Spectrometer

All VNIR (418 to 918 nm, 4.5 nm sampling interval) data products are available as orthorectified raster files (ENVI file format) at a nominal 1 m spatial resolution; Google Earth overlays (KML) are available for the NIR band.

Radiance: Calibrated radiance data is provided for individual swaths in radiometric units ( $W m^{-2} sr^{-1} nm^{-1}$ ).

At-sensor reflectance: Computed as the ratio between observed upwelling radiance and downwelling hemispheric irradiance; corrected for differences in cross-track illumination and BRDF using an empirically derived multiplier. At a nominal flying height of 335 m AGL, the at-sensor reflectance is a close approximation of surface reflectance. Available for individual swaths, and mosaicked for mapped areas using swath observations closest to nadir.

Vegetation indices: Computed from at-sensor reflectance data. These products are used as indicators of canopy properties and condition (e.g., greenness, pigment concentrations).

Ancillary data: Contains acquisition time, aircraft location, sun-sensor geometry, incoming PAR, clearness index, swath ID, and flag indicating nearest neighbor resampling during georegistration.

#### Thermal

Radiant temperature: Computed with 0.98 emissivity and no atmospheric or view angle correction. Available as Google Earth overlay (KML) and raster data product (GeoTIFF) at a nominal 1 m spatial resolution.

#### 8) INSTRUMENT SPECIFICATIONS

##### GPS-INS

Model/Make: RT-4041, GPS and GLONAS enabled; Oxford Technical Solutions, Oxfordshire, UK  
Serial number: 663  
Sampling interval: 250 Hz  
Differential correction: OmniStar HP or G2  
Positional accuracy (1 sigma): 10 to 15 cm horizontal (vertical=horizontal\*1.5)  
Yaw accuracy (1 sigma): 0.1 degree  
Roll accuracy (1 sigma): 0.03 degree  
Pitch accuracy (1 sigma): 0.03 degree  
Antenna: Antcom G5Ant-42AT1 L1/L2 Glonass/GPS/OmniStar  
Post-Processing software: RT Post-Process

##### Scanning lidar

Model/Make: VQ-480; Riegl Laser Measurement Systems, Horn, Austria  
Serial number: S9997785  
Laser wavelength: 1550 nm  
Pulse width: 3 ns  
Pulse energy: 2817 nJ in 25 mm  
Beam divergence: 0.3 mrad  
Nominal footprint size: diameter =  $\tan(\text{beam divergence}/2) * \text{altitude} * 2$   
Laser pulse repetition frequency (PRF): 300 kHz  
Effective measurement frequency:  $0.5 * \text{PRF}$   
Maximum number of returns per pulse: 8  
Field of view: 60 degrees (+/- 30 degrees of nadir)  
Scan mode: line  
Scan rate: 100 lines per second  
Nominal distance between points in a scan line: 0.24 m  
Nominal distance between scan lines: 0.56 m  
Swath size: width =  $\tan(\text{FOV}/2) * \text{altitude} * 2$

Lever arm (ahead, left, above; date): 0.222, 0.310, 0.719 m (16 June 2011)  
Boresight (roll, pitch, yaw; date): 0.01810, 0.01337, -0.27298 degrees (14 July 2011)  
Post-Processing software: RiProcess

#### Profiling lidar

Model/Make: LD321-A40; Riegl Laser Measurement Systems, Horn, Austria  
Serial number: 9995315  
Laser wavelength: 905 nm  
Pulse width: 7.6 ns  
Pulse energy: 503 nJ in 50 mm  
Beam divergence: 2.65 mrad  
Nominal footprint size:  $\text{diameter} = \tan(\text{divergence}/2) * \text{altitude} * 2$   
Laser pulse repetition frequency (PRF): 10 kHz  
Pre-Detection averaging: 100 digitized samples  
Effective measurement frequency: 100 Hz  
Maximum number of returns per pulse: 5 (3 maximum first returns, 2 maximum last returns)  
Field of view: 0 degrees (nadir)

Digital SLR: none

#### Imaging spectrometer

Model/Make: Hyperspec model 1002A-00451; Headwall Photonics, Fitchburg, MA  
Serial Number: G4-105  
Camera: Adimec model RA1000m/D\_DFG  
Serial Number: 830016  
Focal plane array: pushbroom, 1004 cross track pixels  
Frame rate: 50 Hz  
Lens/FOV: 8 mm lens, f/2; ~50 degree  
Sensor size: 7.4 mm  
Integration time: 20 msec  
Sensor range: 417-1008 nm  
Spectral band width (FWHM): ~8 to 15 nm  
Sampling resolution: 1.5 nm (401 bands)  
Resampled resolution: 418 to 919 nm in 4.5 nm bands (114 bands)  
Quantization: 12 bit

#### Thermal camera

Model/Make: Gobi-384; Xenics, Leuven, Belgium  
Serial number: GOBI-1413  
Sensor: Uncooled microbolometer  
Focal plane array: 384 x 288 on 25 um pixels  
Data output: degrees Celsius  
Frame rate: 25 Hz  
Sensitivity: 8 to 14 um  
Quantization: 16 bit

#### Downwelling irradiance

Model/Make: USB-4000; Ocean Optics, Dunedin, FL  
Serial number: USB4F02529  
FOV: 180 degrees (cosine diffusor)  
Integration time: 33 ms  
Sample averaging: 30  
Sampling interval: 0.6 nm  
Sensor range: 380-1100 nm  
FWHM: 1.5 nm  
Resampled resolution: 418 to 919 nm in 4.5 nm bands (114 bands)  
Quantization: 16 bit

#### 9) PUBLICATIONS

Cook, B. D., L. W. Corp, R. F. Nelson, E. M. Middleton, D. C. Morton, J. T. McCorkel, J. G. Masek, K. J. Ranson, and V. Ly. 2013. NASA Goddard's Lidar, Hyperspectral and Thermal (G-LiHT) airborne imager. Remote Sensing 5:4045-4066, doi:10.3390/rs5084045.