

METADATA FOR NASA GODDARD'S LIDAR, HYPERSPECTRAL AND THERMAL (G-LiHT) AIRBORNE IMAGER v2.0

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

Bruce Cook, G-LiHT PI: [bruce.cook@gsfc.nasa.gov](mailto:bruce.cook@gsfc.nasa.gov), 301.614.6689  
Larry Corp, G-LiHT Instrument Scientist: [lawrence.a.corp@nasa.gov](mailto:lawrence.a.corp@nasa.gov), 301.614.6619  
Address: NASA Goddard Space Flight Center  
Biospheric Sciences Laboratory, Mail Code 618  
8800 Greenbelt Rd  
Greenbelt, MD, 20771  
Website: <http://gliht.gsfc.nasa.gov>

2) CAMPAIGN INFORMATION

Date(s): 17 April - 2 May 2018  
Time of day: Targeted +/-3 hours from solar noon  
Location: Tropical forests of Puerto Rico  
Description: Forest damage and recovery following Hurricanes Irma and Maria in Puerto Rico  
Research project: Quantifying Forest Response To Hurricanes Irma And Maria In Puerto Rico Using The G-LiHT Instrument Package  
Funding source: US Department of Interior, US Department of Agriculture, NASA

3) FLIGHT PLANS

Mapped areas, and single and multi-pass transects with 30% overlap over USFS FIA and research plots across the island.

4) ACQUISITION DETAILS

Aircraft: Dynamic Aviation A90 King Air (N87Q)  
Pilots: Justice Pousson, Matthew Staley and Chan Hee Choi  
G-LiHT operator(s): Larry Corp, NASA GSFC  
Nominal altitude (AGL): 335 m AGL  
Nominal velocity: 110-150 kt  
Other:

5) FIELD OBSERVATIONS

Weather: Variable sky conditions  
Other notes: VFR

6) OUTPUT FILE NAME(S)

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); lidar apparent reflectance ("Intensity" field; -25 to 5 dB for 2 byte range); and lidar ID ("User" field; 1=old, 2=new). 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: Applanix POS AV V6 (Richmond Hill, Ontario, Canada)

Serial number: 6693 (GPS), 121016 (INS)

Sampling interval: 200 Hz

Differential correction: POSPac MMS v8 with Centerpoint RTX (Real Time eXtended)

Positional accuracy: <10 cm horizontal, <20 cm vertical (RMS)

Yaw accuracy (1 sigma): 0.0050 degree (RMS)

Roll and pitch accuracy: 0.0025 degree (RMS)

Antenna: Trimble AV 39 L1/L2 GLONAS/GPS/GALILEO/QZSS/SBAS/BeiDou

##### Scanning lidars (2)

Model/Make: VQ-480i; Riegl Laser Measurement Systems, Horn, Austria

Serial numbers: "old" (upgraded from VQ-480) S9997785; "new" (purchased in 2017) S2220331

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: 150 lines per second

Nominal distance between points in a scan line: 0.24 m

Nominal distance between scan lines: 0.42 m

Swath size: width =  $\tan(\text{FOV}/2) * \text{altitude} * 2$

Lever arm from IMU to antenna (x,y,z; date); 0.303, 0.000, -1.168 m (March 2017)

IMU Frame w.r.t. Ref. Frame (x,y,z; date): 0.000, 0.000, -90.000  
Lever arm from IMU to "old" lidar (x,y,z; date): 0.543, 0.005, 0.1736 (March 2017)  
Lever arm from IMU to "new" lidar (x,y,z; date): 0.004, -0.00039, 0.16958 (March 2017)  
Boresight for "old" lidar (roll, pitch, yaw; date): -0.36784, 0.05752, 0.14547 degrees (17 April 2018)  
Boresight for "new" lidar (roll, pitch, yaw; date): 0.05063, -0.11509, -0.10060 degrees (17 April 2018)  
Post-Processing software: RiProcess

#### Digital RGB Camera

Camera: Phase One iXU1000-R  
Lens: Rodenstock HR Digaron-W, 50mm f/4  
FOV: 56.2 x 43.6 degrees (cross track x along track)  
Pixels: 11608 x 8708 (cross track x along track) = 101 megapixel  
Sensor size: 53.4 x 40 mm (cross track x along track)  
Shutter speed: 1/1600 s  
Aperture: f/5.0  
ISO: 200  
White balance: daylight  
Frame rate: 1 Hz  
Image format: IIQ  
Quantization: 16-bit

#### Imaging spectrometers

Model/Make: Microhyperspec E Series with shutter; Headwall Photonics, Fitchburg, MA  
Serial Number: UVS-230  
Camera: pco edge 5.5  
Serial Number: 61001572  
Focal plane array: pushbroom, 645 cross track pixels after 2x binning  
Frame rate: 75 Hz  
Lens/FOV: 8 mm lens, f/1.4, achromatic  
Sensor size: 21.8 mm diagonal, 6.5  $\mu$ m pixel pitch  
Integration time: 13.3 msec (75 Hz)  
Sensor range: 400-1000 nm  
Spectral band width (FWHM): TBD nm  
Sampling resolution: 3.3 nm (185 bands after 2x binning)  
Resampled resolution: 400 to 1000 nm in 4.5 nm bands (133 bands)  
Quantization: 16-bit

Model/Make: FIREFLY Fluorescence spectrometer; Headwall Photonics, Fitchburg, MA  
Serial Number: CFL-001  
Camera: pco edge 5.5  
Serial Number: 61001572  
Focal plane array: pushbroom, 266 cross track pixels after 6x binning  
Frame rate: 37.5 Hz  
Lens/FOV: 25 mm, telecentric  
Sensor size: 21.8 mm diagonal, 6.5  $\mu$ m pixel pitch  
Integration time: 26.6 msec (37.5 Hz)  
Sensor range: 670-780 nm  
Spectral band width (FWHM): 0.18 to 0.14 nm  
Sampling resolution: 0.05 nm (2160 bands)  
Resampled resolution: None  
Quantization: 16-bit

#### Thermal camera

Model/Make: Gobi-640 GigE Vision; Xenics, Leuven, Belgium  
Lens: athermalized 14.25mm f/1.2  
Serial number: 8708  
Sensor: Uncooled microbolometer  
Focal plane array: 640 x 480 on 17  $\mu$ m pixels  
Data output: degrees Celsius  
Frame rate: 50 Hz  
Sensitivity: 8 to 14  $\mu$ m  
Quantization: 16-bit

#### Downwelling irradiance spectrometers (2)

Model/Make: FLAME-T, with 350-1000 filter and #3 grating; Ocean Optics, Dunedin, FL  
Serial number: FLMT01800

FOV: 180 degrees (cosine diffusor)  
Integration time: 33 ms  
Sample averaging: 30  
Sampling interval: 0.218 nm  
Sensor range: 344-1037 nm  
FWHM: ~1.5 nm  
Resampled resolution: 400 to 1000 nm in 4.5 nm bands (133 bands)  
Quantization: 16-bit

Model/Make: QEPro with >590 longpass filter and H6 grating; Ocean Optics, Dunedin, FL  
Serial number: QEP01158  
FOV: 180 degrees (cosine diffusor)  
Integration time: 1 s  
Sample averaging: 1  
Sampling interval: 0.175 nm  
Sensor range: 650-811 nm  
FWHM: 0.44 to 0.32 nm  
Resampled resolution: None  
Quantization: 18-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.