METADATA FOR NASA GODDARD'S LIDAR, HYPERSPECTRAL AND THERMAL (G-LiHT) AIRBORNE IMAGER v2.6

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1) CONTACT INFORMATION

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2) CAMPAIGN INFORMATION

Date(s): 27 July - 6 August 2021
Time of day: Targeted +/-3 hours from solar noon
Location: Eastern CONUS
Description: 1) Functional test flight of G-LiHT v2.6 with fine-resolution, 4-band stereo aerial camera (3 cm GSD, RGB+NIR); 2) diurnal acquisitions over Smithsonian Environmental Research Center (NEON and ForestGEO site) that have been flown previously, in support of a NASA Surface Topography & Vegetation (STV) project; and 3) repeat acquisitions over study sites in Maine to assess changes in forest structure and function for NASA Carbon Monitoring System (CMS) and Established Program to Stimulate Competitive Research (EPSCoR) projects.
Funding sources: NASA Terrestrial Ecology (TE), SVT, CMS and EPSCoR

3) FLIGHT PLANS

Mapped areas, and single and multi-pass transects with 30% overlap over research plots.

4) ACQUISITION DETAILS

Aircraft: Dynamic Aviation A90 King Air (N80Y)
Pilots: Justin Marrow (Captain) and Garrett Dougan (First Officer)
G-LiHT operator(s): Larry Corp, Bruce Cook, Jesse Barber and Hank Margolis; NASA GSFC/HQ
Nominal altitude (AGL): 335 m AGL
Nominal velocity: 110-150 kt

5) FIELD OBSERVATIONS

Weather: Variable sky conditions during acquisitions, ranging from clear, partially cloudy, to completely overcast
Other notes: Nominal flying altitude was beneath cloud base, and collections were discontinued due to precipitation and poor visibility

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(beam divergence/2)*altitude*2
Laser pulse repetition frequency (PRF): 300 kHz
Effective measurement frequency: 0.5*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(FOV/2)*altitude*2
Lever arm from IMU to antenna (x,y,z; date); 0.250, 0.056, -1.058 m (July 2021)
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): -0.18728, 0.03747, 0.05448 (July2021)
Boresight for "new" lidar (roll, pitch, yaw; date): 0.04656, -0.12276, -0.08425 (July2021)
Post-Processing software: RiProcess v 1.8.6

Digital RGB and NIR Cameras

Camera: Phase One iXM-RS100F-RS (RGB) and iXM-RS100F-Acr (NIR)

Lens: Rodenstock RS 50mm-Ar, 50mm f/4
FOV: 56.2 × 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: 1/1000 s
Aperture: f/4.0
ISO: 200 (RGB) and 400 (NIR)
White balance: daylight
Frame rate: 1 Hz
Image format: IIQ
Quantization: 16-bit

VNIR Imaging spectrometer
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 µm pixel pitch
Integration time: 13.3 msecs (75 Hz)
Spectral band width (FWHM): 6 nm
Sampling resolution: 3.3 nm (185 bands after 2x binning)
Spectral Range: 400 to 1000 nm
Quantization: 16-bit

SWIR Imaging spectrometer
Model/Make: Microhyperspec SWIR with shutter; Headwall Photonics, Fitchburg, MA
Serial Number: UVS-366
Focal plane array: pushbroom, 192 cross track pixels after 2x binning
Frame rate: 75 Hz
Lens/FOV: 25 mm lens, f/1.4, achromatic
Sensor size: 21.8 mm diagonal, 24 µm pixel pitch
Integration time: 13.3 msecs (75 Hz)
Spectral band width (FWHM): 10 nm
Sampling resolution: 9.5 nm (172 bands)
Spectral Range: 890 to 2526 nm
Quantization: 16-bit

Downwelling irradiance spectrometer
Model/Make: Spectral Evolution SR-3500
Serial number: 18980N7
FOV: 180 degrees (cosine diffusor)
Integration time: 15,30,30 ms
Sample averaging: 10
Sensor range: 350-2500 nm
FWHM: 3nm, 8nm, 6nm
Resampled resolution: 1nm
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 um pixels
Data output: degrees Celsius
Frame rate: 50 Hz
Sensitivity: 8 to 14 um
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.