Metadata for "Landscape-scale Characterization of Arctic Tundra Vegetation Composition, Structure, and Function with a Multi-sensor Unoccupied Aerial System: Supporting Data"

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Airborne remote sensing data collected using the Brookhaven National Laboratory's (BNL) heavy-lift unoccupied aerial system (UAS) octocopter platform – the Osprey – operated by the Terrestrial Ecosystem Science and Technology (TEST) group (https://www.bnl.gov/testgroup). This package includes data from three flights flown over the NGEE-Arctic Council, Kougarok and Teller sites in July, 2018. The Osprey is a multi-sensor UAS platform that simultaneously measures very high spatial resolution optical red/green/blue (RGB) and thermal infrared (TIR) surface "skin" temperature imagery, as well as surface reflectance at 1 nm intervals in the visible to near-infrared spectral range from ~350 – 1000 nm measured at regular intervals along each flight path. Derived image products include ortho-mosaiced RGB and TIR images, an RGB-based digital surface model (DSM) using the structure from motion (SfM) technique, digital terrain model (DTM), and a canopy height model (CHM). In addition, a VNIR surface reflectance file is provided for the trigger locations collected during each flight campaign. Ancillary aircraft data, flight mission parameters, and general flight conditions provided by the onboard flight and data collection computers are also included. Unprocessed and processed data products are included in this package (processing levels 0-3). Data and metadata are provided as text (*.txt, *.json, *.kml, *hdr, *.enp), tabular (*.dat, *.csv, *.waypoint, ENVI format (no extension)), point cloud (*.laz), image (*.jpg, *.tif, *png) and Cloud Optimized GeoTiff (*.tif) formats. This metadata document contains flight campaign, instrument and file metadata, along with a description of data processing levels, data products and file naming scheme.

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This section provides technical details about the platform and sensor specifications of the 'Osprey' UAS developed by BNL.

Platform Details:

Airframe: CarbonCore Cortex X8 Heavy-Lift airframe (CarbonCore Ltd, York, North Yorkshire, United Kingdom)
Maximum gross takeoff weight: 12.8 kg (including airframe)
Motor type (s): Tiger motor (T-Motors)
Propeller type (s): T-Motor carbon fiber propellers
Flight controller: 3DR PixelHawk PX4
Gimbal type (s): Gremsy H3 gimbal
WiFi antenna (s): Nanostation Loco M2
Radio (s): 915 Mhz x 2
Handheld remote control: Futaba 14-channel computer radio system

Sensor Specifications:

Digital SLR:
Camera: Canon EOS M6

Lens: Canon Zoom Lens EF-M 15 - 45 mm
Focal length: 15 - 45 mm
FOV: 44 - 100 degrees
Image area and size: DX 6000 × 4000 = 24 megapixel
Shutter speed: 1/200 s
ISO: 100/m
Focus: auto, infinity
White balance: sunlight
Image format: jpg
Quantization: 12-bit

Thermal camera:
Model/Make: ICI
Sensor: 9640 P-series
Serial number: 6001194
Focal length: 12.5 mm
Image area and size: DX 640 × 480
Data output: degrees Celsius
Accuracy: +/- 1 degree
Frame rate: 30Hz
Sensitivity: 7 – 14 µm
Quantization: 14-bit

Point spectrometer:
Model/Make: Ocean Optics FLAME spectrometer x 2
Downwelling FLAME foreoptic: Ocean Optics CC-3-DA cosine corrector
Downwelling FLAME Serial number: 03923
Upwelling FLAME foreoptic: Ocean Optics 74-UV variable FOV lens set to 14 degrees
Upwelling FLAME Serial number: 03924
Integration time: 1 - 2 s
Spectral range: 350 - 1000 nm
Spectral resolution: 1.5 nm
Resampled resolution: 1 nm spectral resolution from 400 - 900 nm
Quantization: 16 bit

Platform Reference:

Yang D.; Meng R.; Morrison M.D; McMahon A.; Hantson W.; Hayes D.J.; Breen A.L.; Salmon V.G.; Serbin S.P., 2020. A Multi-Sensor Unoccupied Aerial System Improves Characterization of Vegetation Composition and Canopy Properties in the Arctic Tundra. *Remote Sensing*. 12(6), 2638; doi:10.3390/rs12162638

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This section summarizes the UAS campaign, flight details, and data products. Detailed information in each sub-section may change based on the study site, in-situ flight specifications, and generated data products. The data products listed in this document are the desired products produced from the Osprey UAS. The products are processed in the form of different levels. For most end users, we suggest using L2 and L3 products which have been georeferenced to the right location and to remove spatial distortions.

UAS Campaign Information:

Research project: DOE NGEE Arctic (https://ngee-arctic.ornl.gov/)

NGEE Arctic Site(s): Kougarok (MM64), Council (MM71), Teller (MM27)

Location: Seward Peninsula, Alaska

Date (s): July 22 – July 25, 2018

Total number of flights: 3

Flight crew: Shawn Serbin, Andrew McMahon, Daryl Yang

Flight Details:

Flight Name	Site	Date	Start of Flight (UTC)	End of Flight (UTC)	Flying Height	Forward Overlap	Side Overlap	Flight Speed
Council_20180722_Flight3	Council	20190722	12:03 pm	12:08 pm	40 m	85%	85%	5 m/s
Kougarok_20180725_Flight6	Kougarok	20180725	3:27 pm	3:32 pm	40 m	85%	85%	5 m/s
Teller_20180723_Flight5	Teller	20180723	1:36 pm	1:39 pm	40 m	85%	85%	5 m/s

Data Products:

L0 – raw data collected with the Osprey platform

1) Flight mission telemetry and trigger record (s): MoDaCS directory (*.kml, *.txt, *.waypoint)
2) Spectral reflectance json file (s): MoDaCS directory (***_USB2000+_Pair.json, ***_USB2000+_Pair_Log.txt)
3) Optical RGB photo (s): Canon_Photos (***.JPG)
4) Thermal IR binary image (s): Thermal_IR (***.dat)

L1 – Basic post-processing (image products 1), 2), 3), 4) are derived using Structure-from-Motion in Metashape software; spatial information is included in each imagery, but there might be minor spatial registration error varying from image to image; for more detailed description about these products regarding resolution, spatial extent, and projection, etc., please see the L1 data description file included in L1 datasets)

1) Optical RGB ortho-mosaic:
   ***_RGB.tif
2) Digital surface model derived from RGB image processing:
   ***_DSM.tif
3) Thermal IR ortho-mosaic:
   ***_TIR.tif
4) Point Clouds derived from RGB image process:
   ***_CloudPoints.laz
5) Spectral reflectance file:
   ***_SurfaceReflectance.csv

L2 – Higher-level data products (orthorectified images that has been georeferenced using ground control points to correct spatial registration error and image distortions; the thermal IR is scaled by a factor of 10 and the canopy height model is scaled by 100; for more detailed description about these products regarding resolution, spatial extent, and projection, etc., please see the L2 data description file included in L2 datasets)

1) Geo-referenced optical RGB ortho-mosaic:

***_RGB.tif

2) Geo-referenced thermal IR ortho-mosaic:
   ***_TIR.tif
3) Canopy height model:
   ***_CHM.tif
4) Digital elevation model:
   ***__DEM.tif

L3 - Higher-level derived data products (in ENVI format, for detailed definition of the classified species and PFTs, please see L3 data description file included in L3 datasets)

1) Species map:
   ***_Species_Map (no file extension)
2) PFT map:
   ***_PFT_Map (no file extension)

Notes

*** represents a prefix for different flights. It represents the study site, acquisition date, and flight identification.

At all product levels (L0-L3) there *.png files that give a preview image of each raster file (i.e. quicklook). At L1-L2 there are also *.json files that provide the four-corner bounding box footprint for the raster maps. For the ENVI files in L3 there are additional header (*.hdr) and, in some cases, autogenerate ENVI pyramid (*.enp) files needed to open the ENVI imagery.