Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Reporting formats for Unoccupied Aerial System (UAS) data and metadata

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ESS-DIVE webinar
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@BrookhavenLab

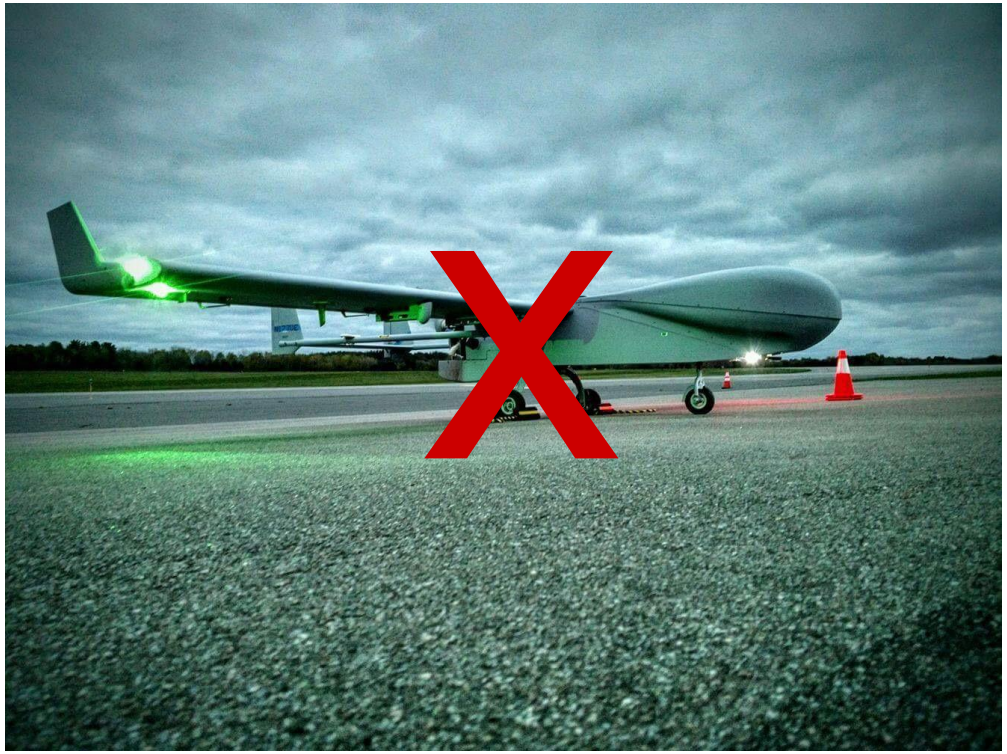
Motivated by FAIR data principles

- Full value of UAS data yet to be realized (Wyngaard et al, 2019)
- Inadequate and variable metadata reporting is a major challenge
- Common metadata makes data more FAIR

Findable
Accessible
Interoperable
Reproducible

(Wilkinson et al, 2016)

Format scope: small UAS data only



Modular approach to data management

- Compatible with other ESS-DIVE formats
- Compatible with established standards & conventions

  e.g. date time variables (ISO 8601) & spatial (EPSG)

data package metadata
file level metadata
domain specific formats
↳ **UAS reporting format**

A community development process

Based on our established research group practice

Searched for existing standards

Align common elements with ESS-DIVE

Open to community input using
GitHub and Google Docs

Questions on scope and methods?

Reporting format overview

- UAS specific metadata capture
  4 metadata categories
- Data product description
  4 processing level classifications
- Supporting materials
  Scope description, instructions for use

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Four categories of UAS specific metadata

- Flight campaign
- Mission details
- Platform description
- Sensor descriptions

Metadata element	variableName	Requirement level	Unit and/or format	Description	Example

How much metadata is needed?

Challenge: balancing desire for detail with ease of use

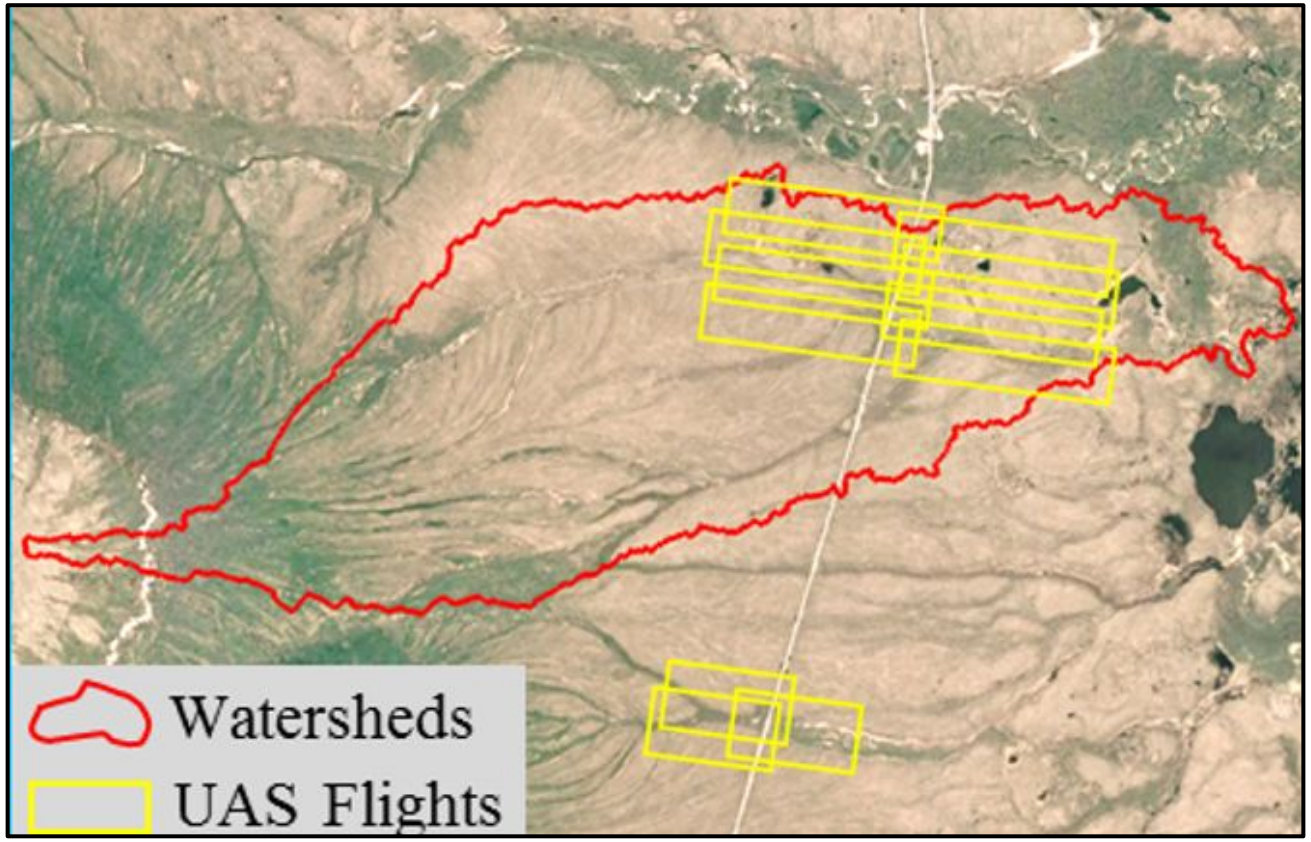
A flexible reporting format is required!

Metadata variables requirement level

- ● required
- ◉ recommended
- ○ optional
- x not applicable

Flight campaign metadata

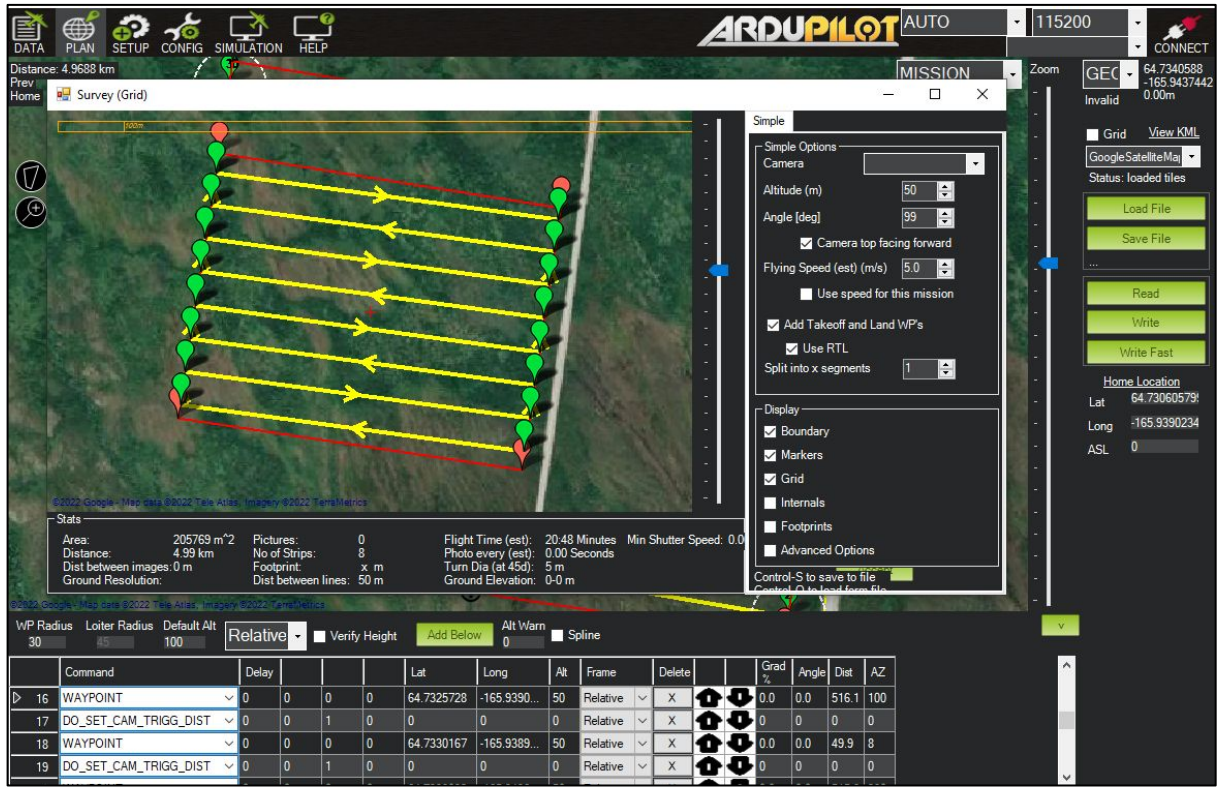
- Research project
- Contact
- Pilot in Command (PIC)
- Location description
- LocationID
- Start date
- End date
- Total number of flights
- Average flight time
- Total flight time
- Permits and waivers
- Base station



required recommended optional

Mission detail metadata: flight info

- Flight name
- Site
- Start Date Time
- End Date Time
- Flight boundary
- Flight height
- Forward overlap
- Side overlap
- Flight speed



● required ◉ recommended ○ optional

Mission detail metadata: weather conditions

- ○ Weather conditions
- ○ Illumination condition
- ○ Light quality
- ○ Cloud cover
- ○ Cloud type
- ○ Surface wetness
- ○ Days since last rain event

● required ◎ recommended ○ optional

UAS platform metadata

● required ◉ recommended ○ optional

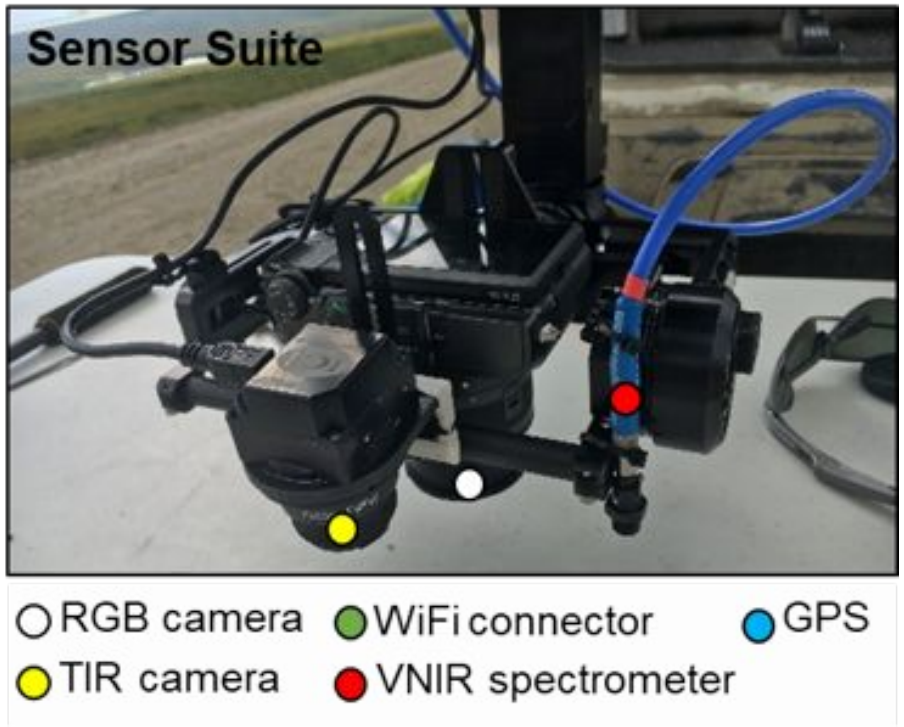
- ● Airframe type
- ● Maximum takeoff gross weight
- ● Make/model
- ● Flight controller
- ◉ Serial number
- ◉ Registration number
- ○ Motor type
- ○ Propellor type
- ○ Battery type
- ○ Gimbal type
- ○ Navigation
- ○ IMU
- ○ Radio & telemetry
- ○ Handheld remote control
- ○ Platform images available

Sensor metadata elements

Specific metadata recommendations have been made for:

- RGB cameras
- Thermal cameras
- Point spectrometers
- Imaging spectrometers
- LiDAR

Metadata elements for novel sensors can be selected from the variable list



Sensor metadata elements

32 variables, with variable names, units, descriptions and examples

Metadata element (some examples…)	Optical RGB camera	Thermal camera	Point spectrometer	Imaging spectrometer	LiDAR
Sensor type	●	●	●	●	●
Manufacturer and model	●	●	●	●	●
Serial number	○	●	●	●	●
Calibration date	✖	◍	◍	◍	◍
Foreoptic	●	●	●	●	✖
Image area and size	○	○	✖	✖	✖
FOV	◍	◍	◍	◍	●
File format	●	●	●	●	●
Measurement units	○	●	●	●	○

● required ◍ recommended ○ optional x not applicable

Sensor metadata example

- csv templates available for standard sensor types
- Platform and sensor metadata files can be reused for multiple campaigns

variableName	metadata
sensorType	point spectrometer
makeModel	Ocean Optics FLAME spectrometer x 2
serialNum	45932; 45933
calibrationDate	2023-01-31
foreoptic	14 deg FOV (upwelling); cosine diffuser (downwelling)

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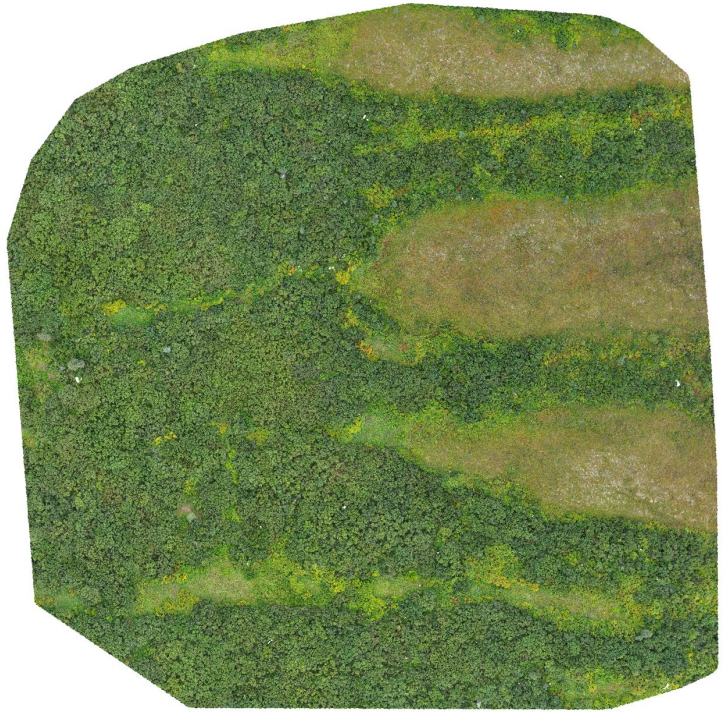
Data processing levels

For improved data discovery

L0: Raw data, telemetry
e.g. RGB image

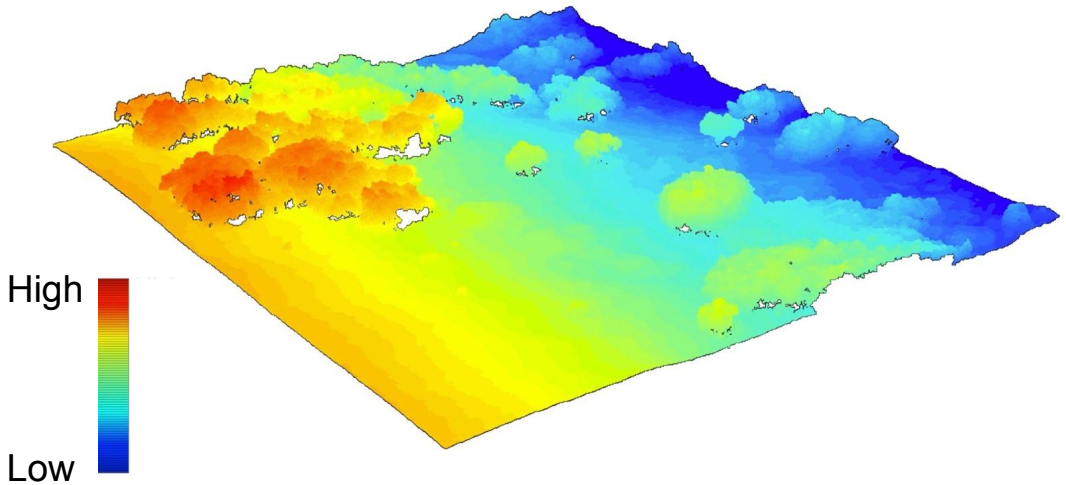
L1: Basic post-processing
e.g. orthophoto mosaic



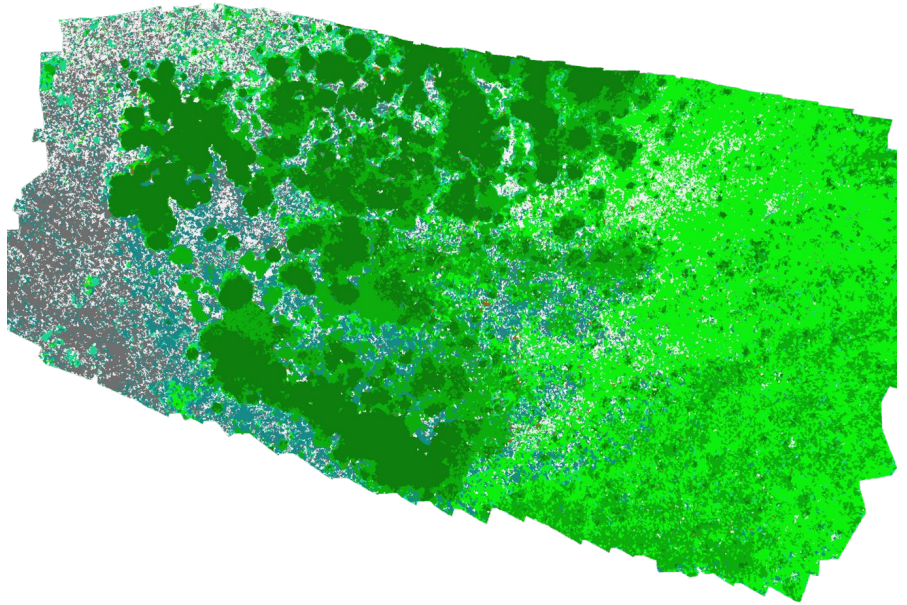
Data processing levels

For improved data discovery

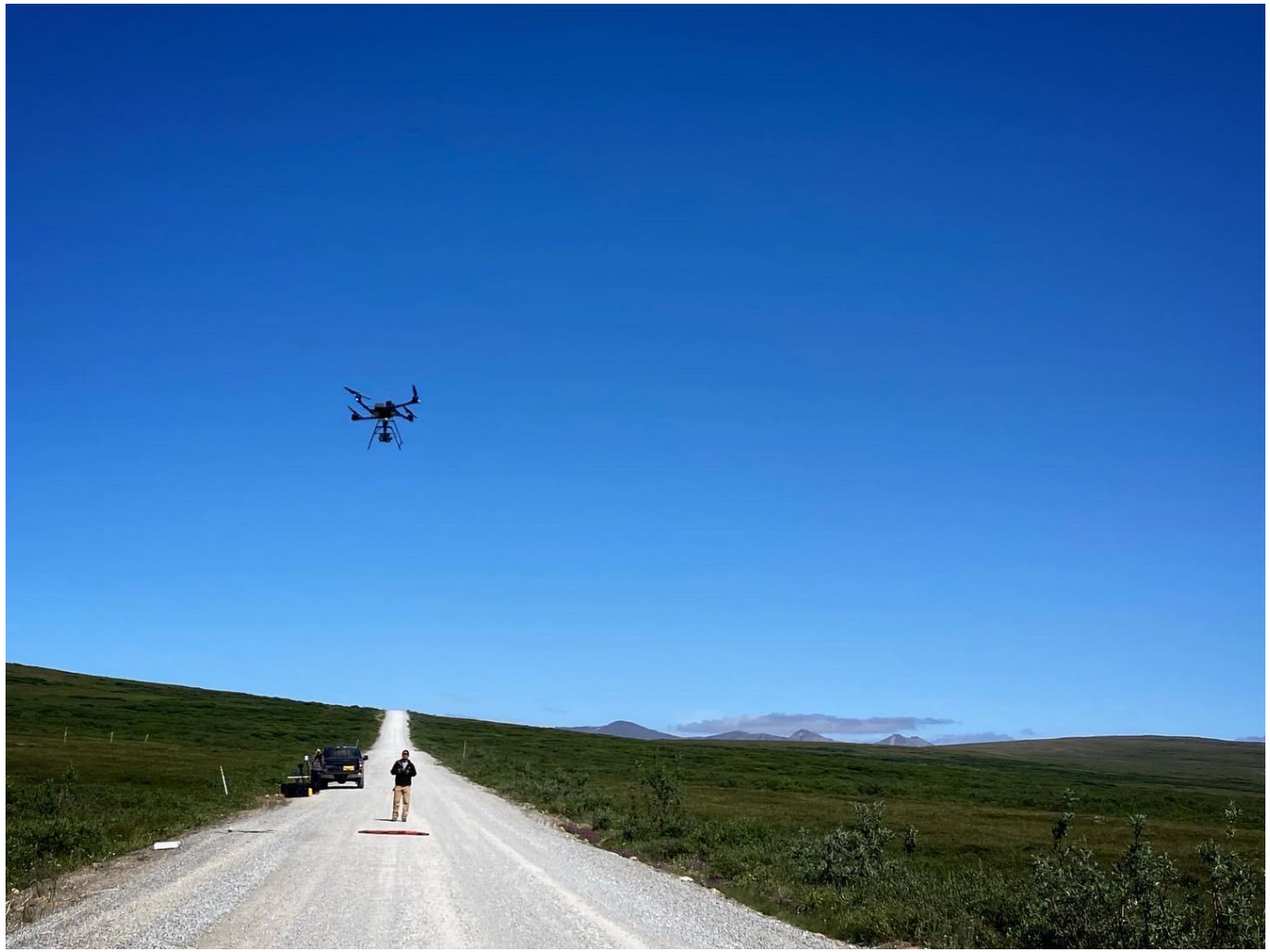
L2: Processed data products
e.g. canopy height model



L3: Derived data products
e.g. plant functional type map



Questions on processing levels?



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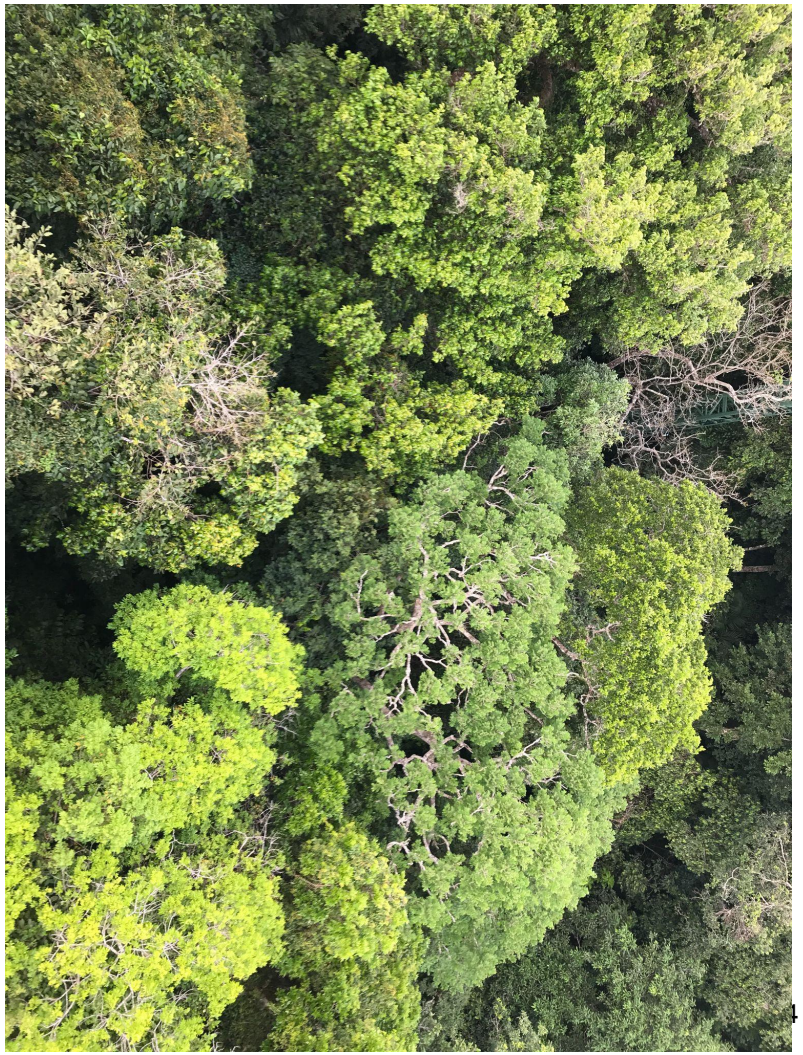
More information on GitHub

In the development phase (now!)

- Project scope
- How to give feedback
- Links to reporting format content
- Instructions for format use

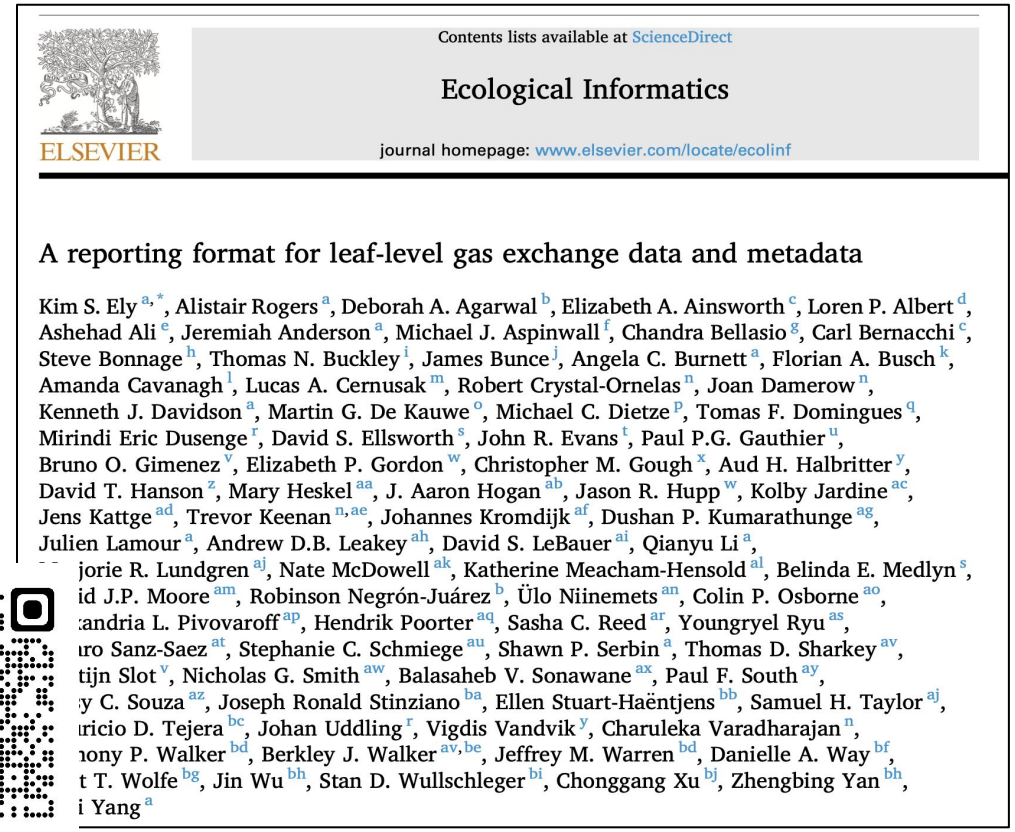
At completion v1.0

- Metadata variable tables
- Metadata templates
- Description of product levels
- Examples



Be a co-author on the paper

- Planned publication about the reporting format
- All contributors to the format invited



Contents lists available at ScienceDirect

Ecological Informatics

journal homepage: www.elsevier.com/locate/ecolinf

A reporting format for leaf-level gas exchange data and metadata

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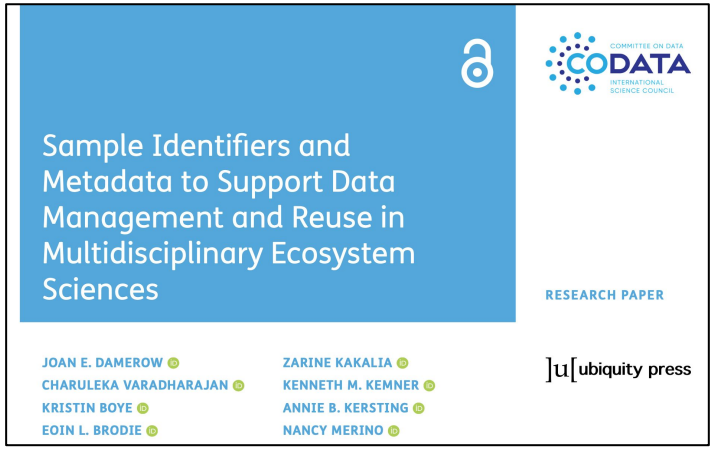

Sample Identifiers and Metadata to Support Data Management and Reuse in Multidisciplinary Ecosystem Sciences

RESEARCH PAPER

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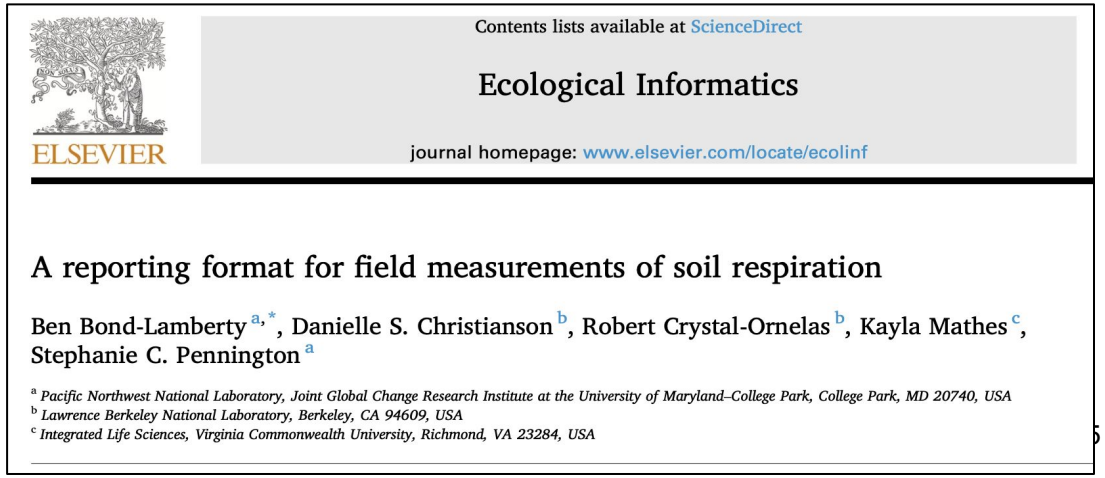

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A reporting format for field measurements of soil respiration

Ben Bond-Lamberty [a,*], Danielle S. Christianson [b], Robert Crystal-Ornelas [b], Kayla Mathes [c], Stephanie C. Pennington [a]

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What next? Feedback is welcome!

- Feedback open until March 2023

  Comment on the draft documentation

  Use GitHub Issues and Discussions

- v.1 published by September 2023

Contact
Kim Ely, kely@bnl.gov

Github

https://github.com/ess-dive-community/essdive-uas