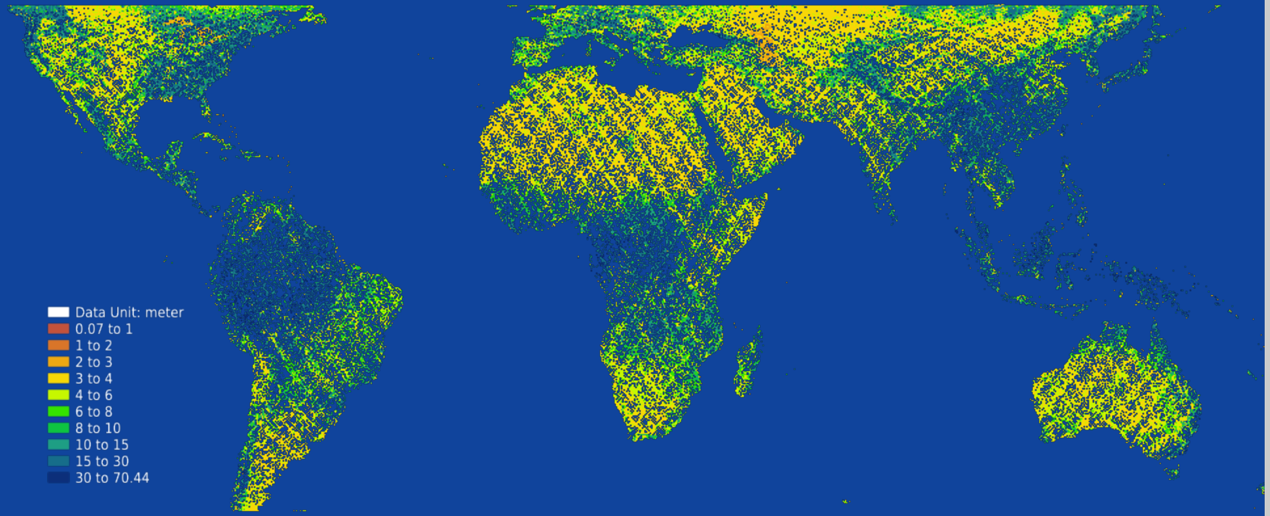
Explore NASA GEDI Aboveground Biomass Datasets, Services, and Tools at ORNL DAAC

Rupesh Shrestha
ORNL DAAC Staff Scientist

Bruce E. Wilson
ORNL DAAC Manager



The Oak Ridge National Laboratory Distributed Active Archive Center for Biogeochemical Dynamics operates under an interagency agreement between NASA and the U.S. Department of Energy

Outline

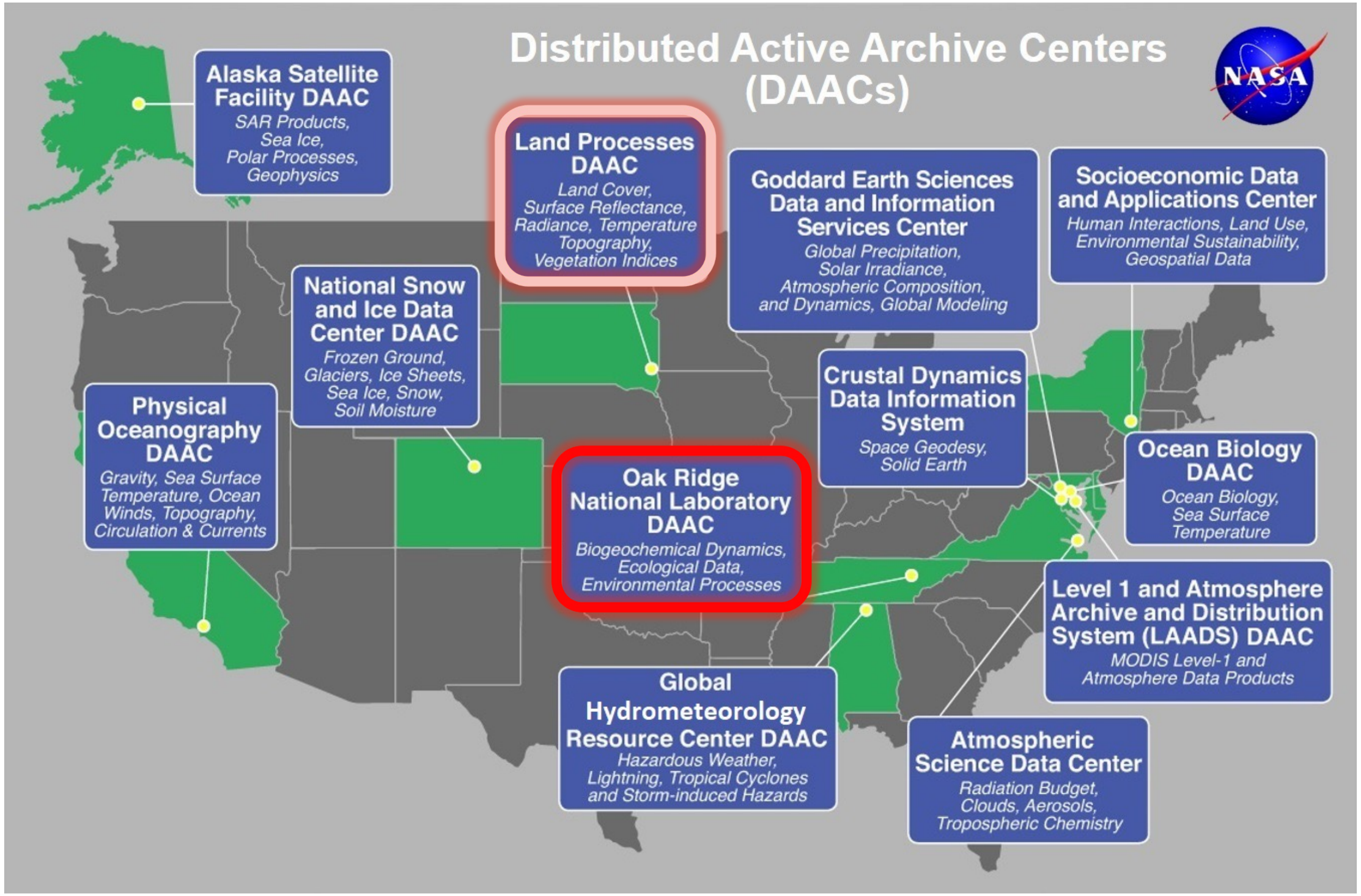
- Introduction (Bruce)
  - ORNL DAAC
  - GEDI mission and Data
  - Available services for GEDI data
    - Earthdata Cloud
- Examples of accessing and using GEDI data (Rupesh)
  - GEDI Level 3, Level 4A, and Level 4B data overview
  - Using S3 Direct Access Tutorial
  - Subsetting GEDI L4A using Harmony

Earth Observing System Data and Information System (EOSDIS) Distributed Active Archive Centers (DAACs)

Distributed Active Archive Centers (DAACs) are collocated with centers of science discipline expertise, archive and distribute NASA Earth Science data products.

https://lpdaac.usgs.gov

https://daac.ornl.gov



The Oak Ridge National Laboratory Distributed Active Archive Center for Biogeochemical Dynamics

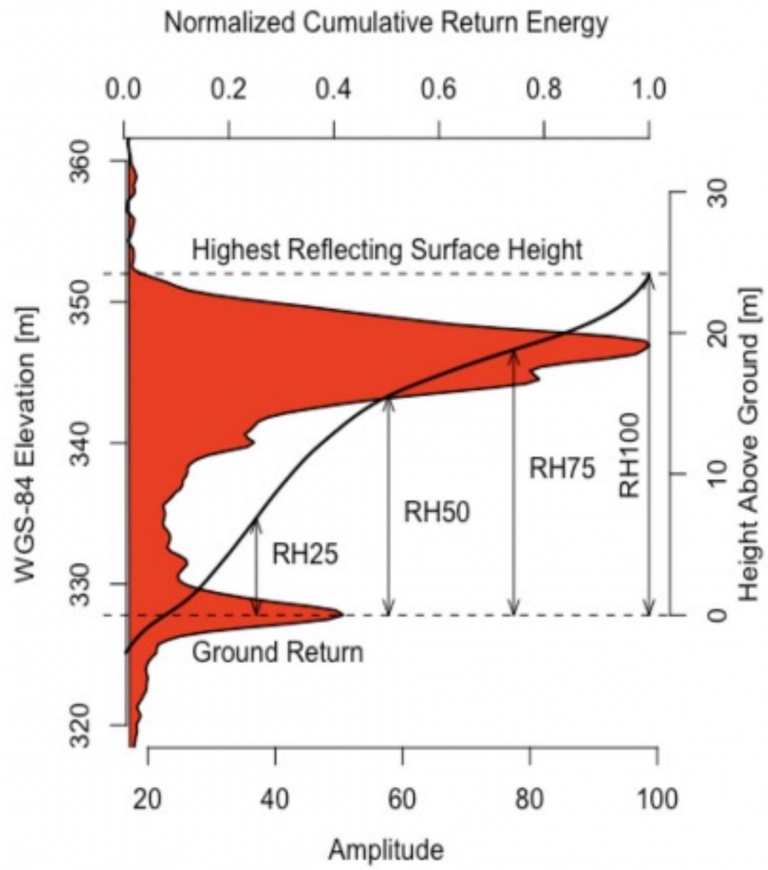
The ORNL DAAC archives and distributes terrestrial ecology data, particularly data from field and airborne campaigns.

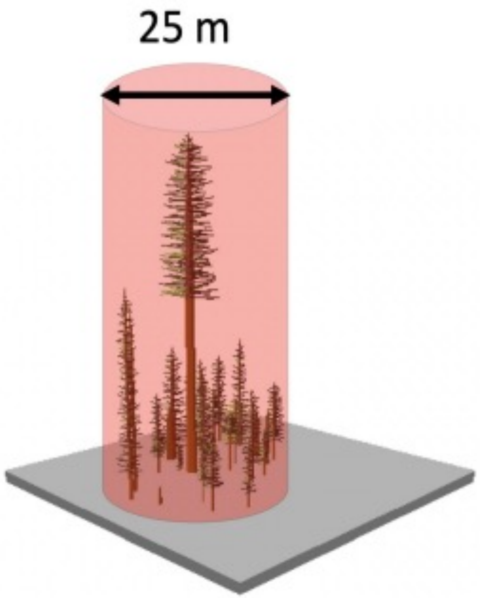
https://daac.ornl.gov

Global Ecosystem Dynamics Investigation

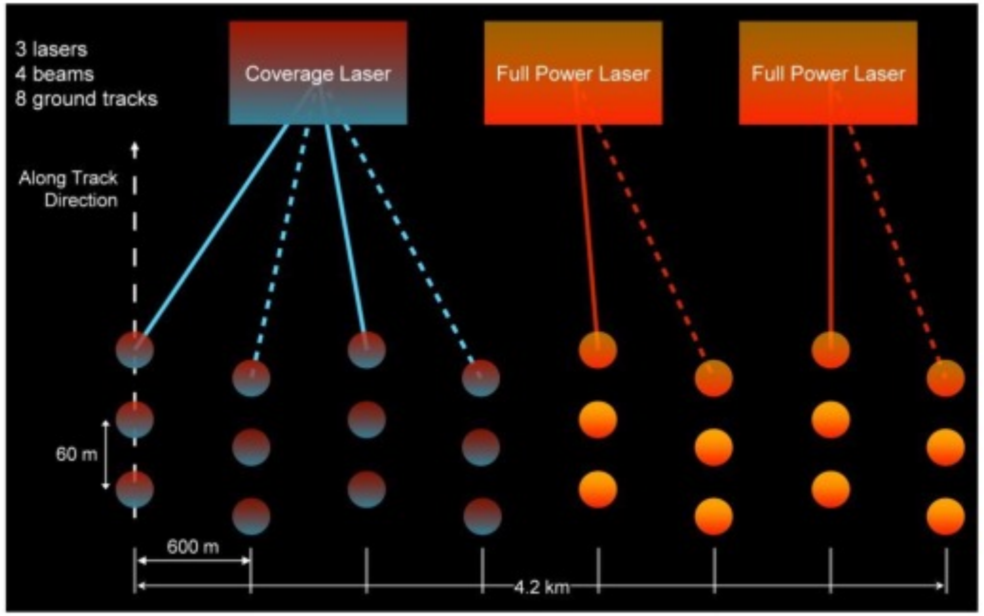
- High resolution laser ranging of the Earth's forests & topography
- Operating on the ISS since April 2019
- 3 lasers, full waveform in NIR
- 8 tracks with 25 m footprints,
  600 m between tracks
- Coverage between +/- 52° latitude
  (ISS orbit)
- https://gedi.umd.edu/
  https://daac.ornl.gov/gedi (ORNL DAAC GEDI data)
  https://bit.ly/2YgIDiE (GEDI Overview at LP DAAC)
  https://youtu.be/xsoMcw4upjs (*Meet GEDI!* video by LP DAAC)

GEDI is full waveform lidar



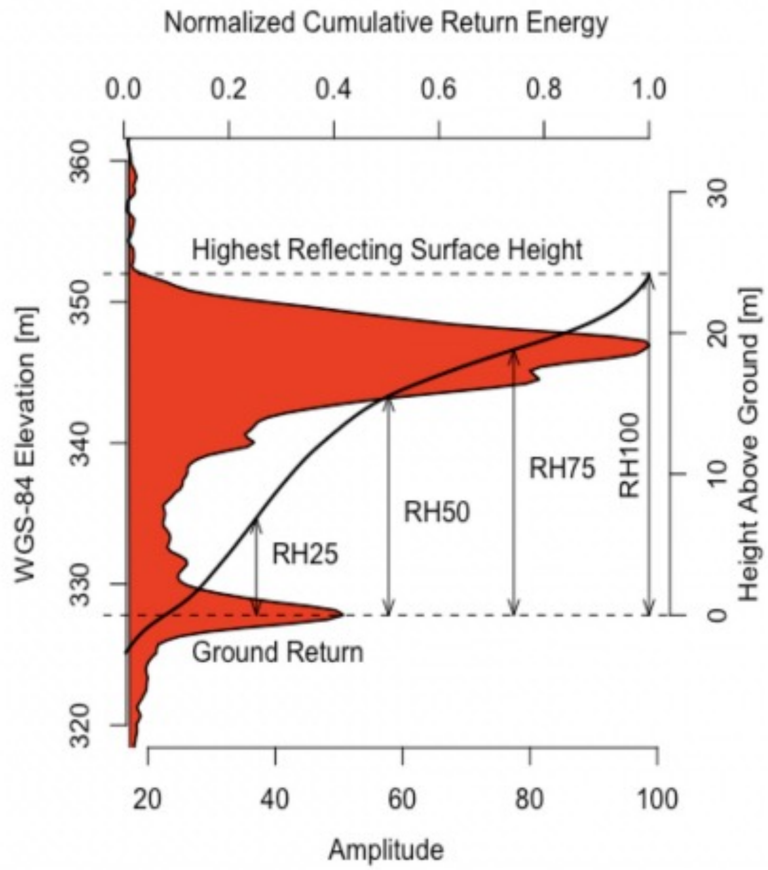


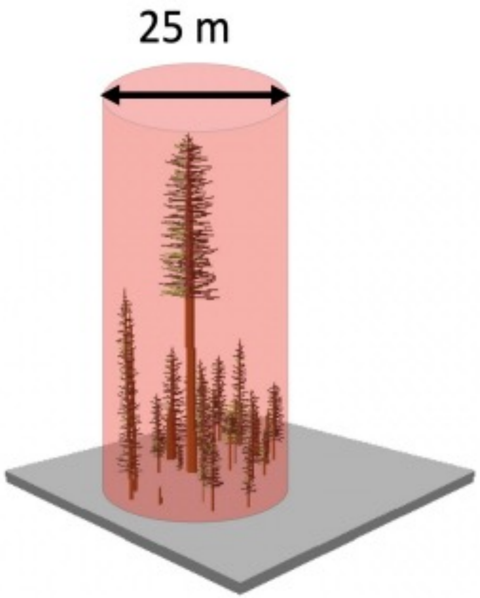
GEDI's sole observable is the lidar waveform which provides ground elevation, canopy height, cover and various profiles and metrics



Level 1: Geolocated Waveform

GEDI is full waveform lidar





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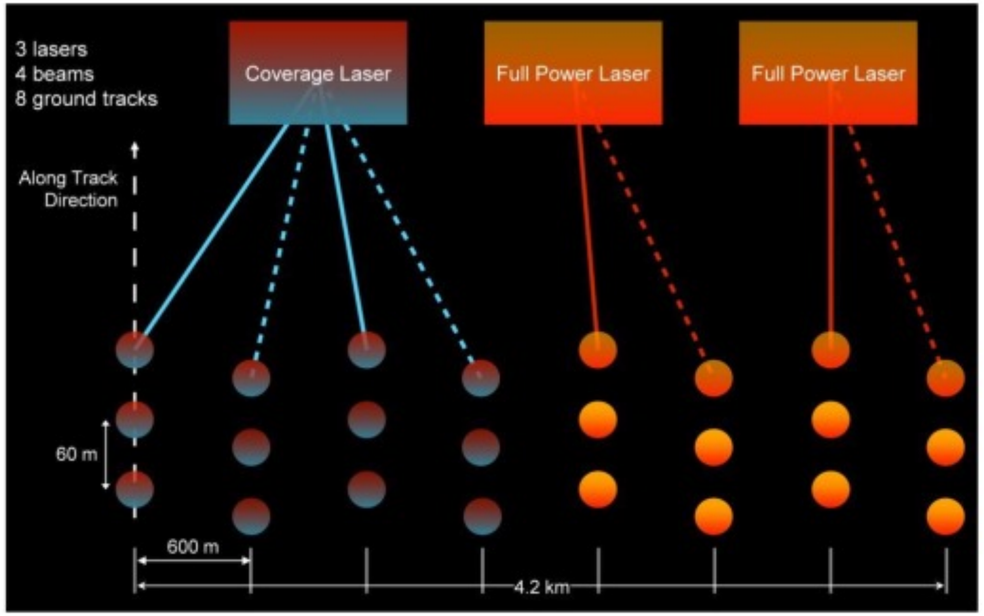
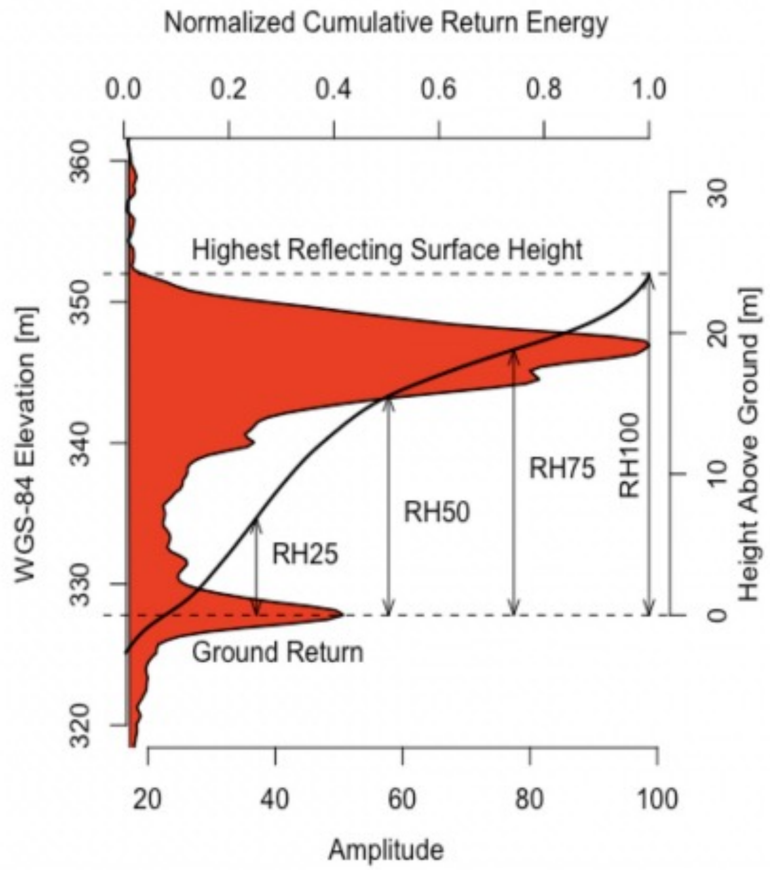
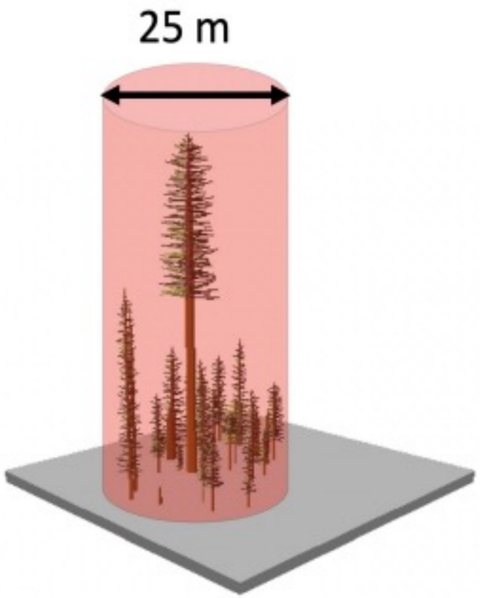


Level 1: Geolocated Waveform

Level 2: Footprint level metrics

GEDI is full waveform lidar





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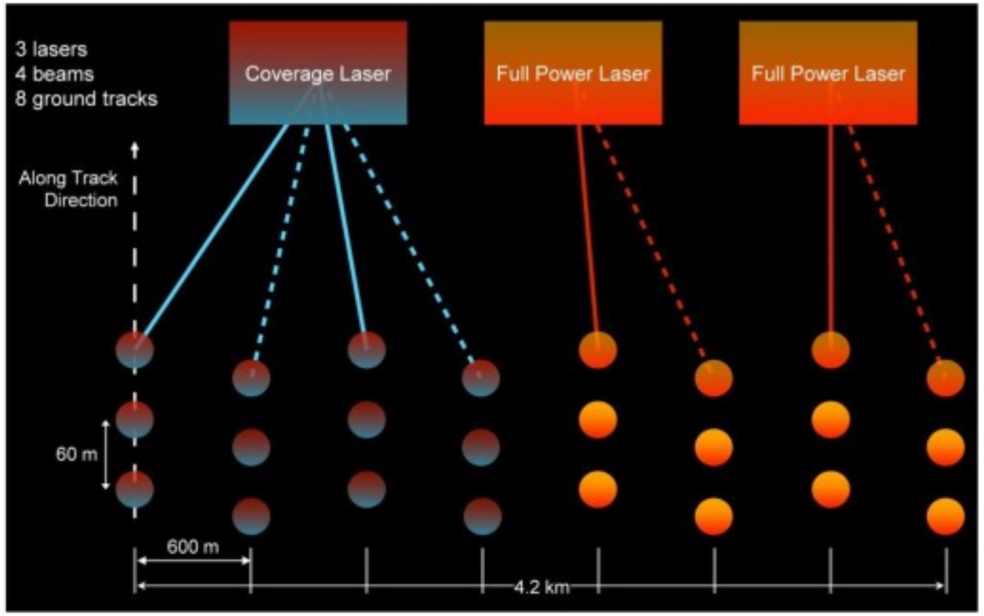
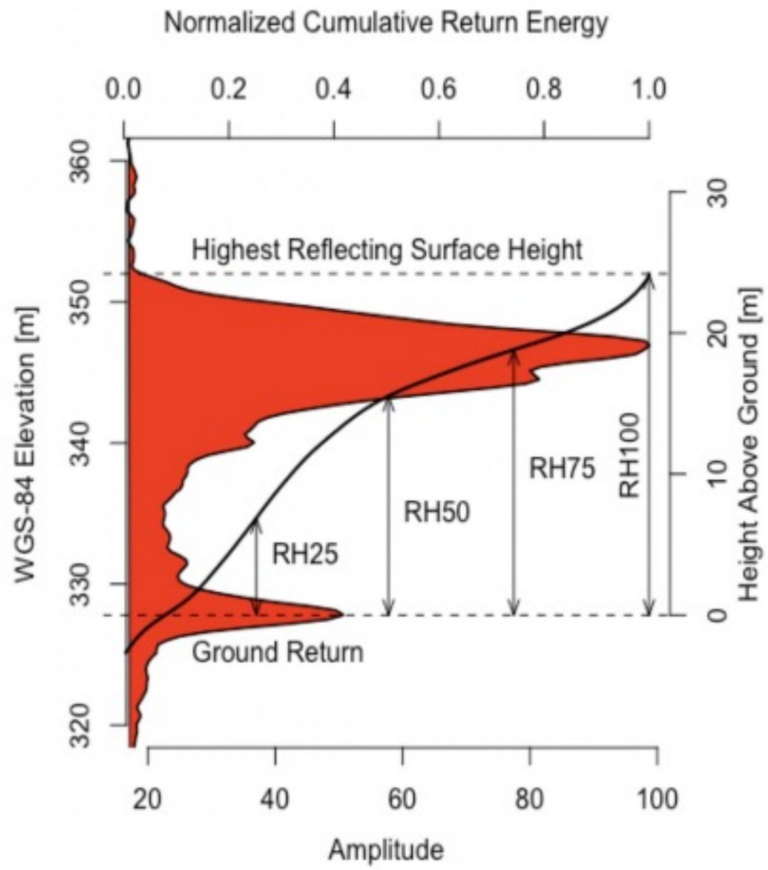
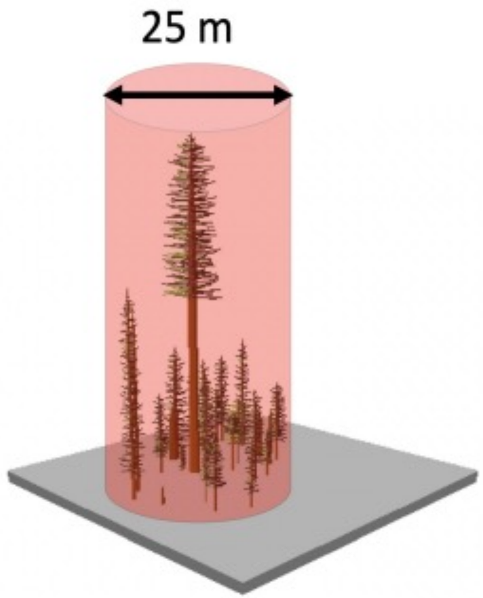


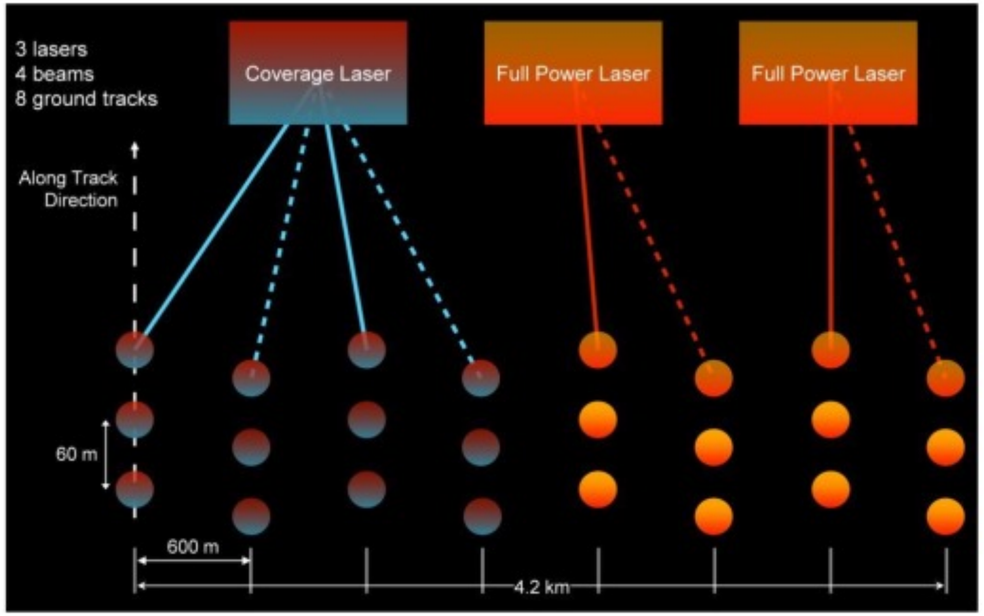
Level 1: Geolocated Waveform
Level 2: Footprint level metrics
Level 3: Gridded metrics

GEDI is full waveform lidar



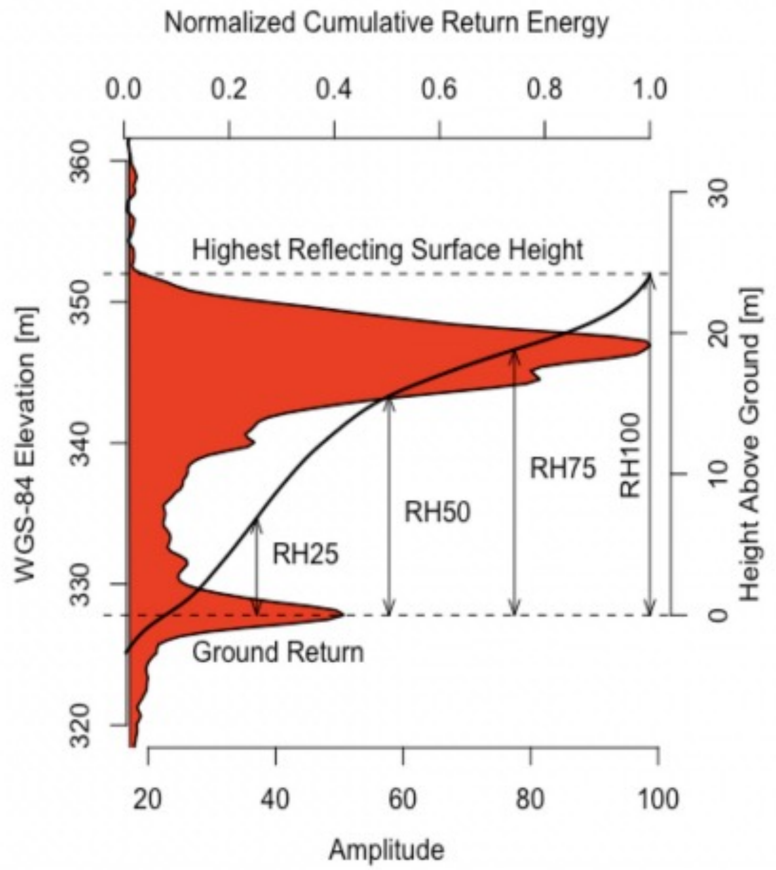


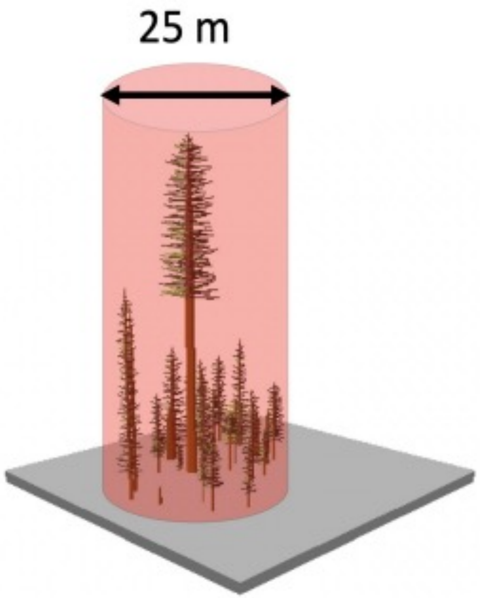
GEDI's sole observable is the lidar waveform which provides ground elevation, canopy height, cover and various profiles and metrics



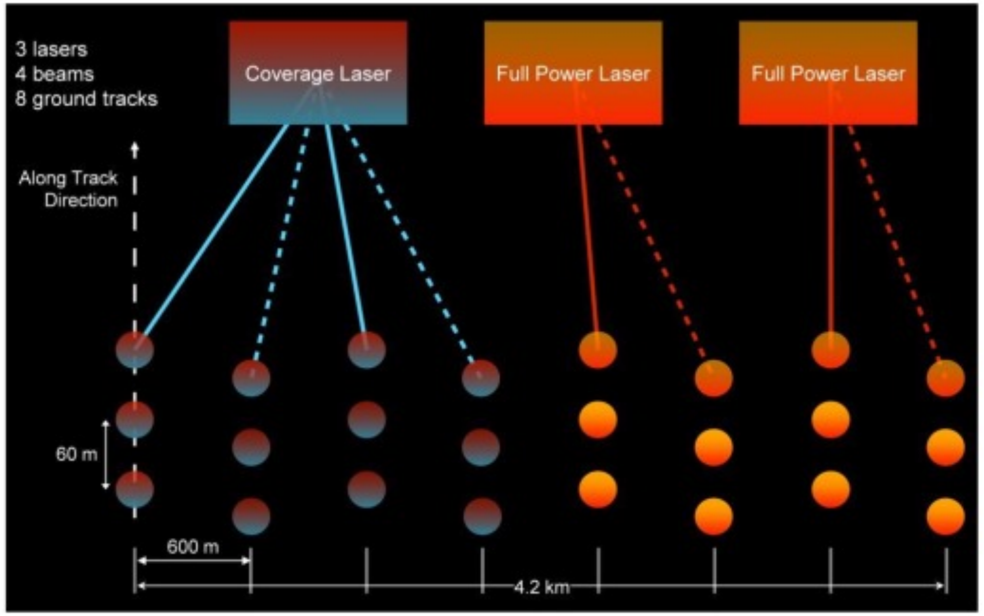
Level 1: Geolocated Waveform
Level 2: Footprint level metrics
Level 3: Gridded metrics
Level 4A: Footprint level aboveground biomass

GEDI is full waveform lidar





GEDI's sole observable is the lidar waveform which provides ground elevation, canopy height, cover and various profiles and metrics



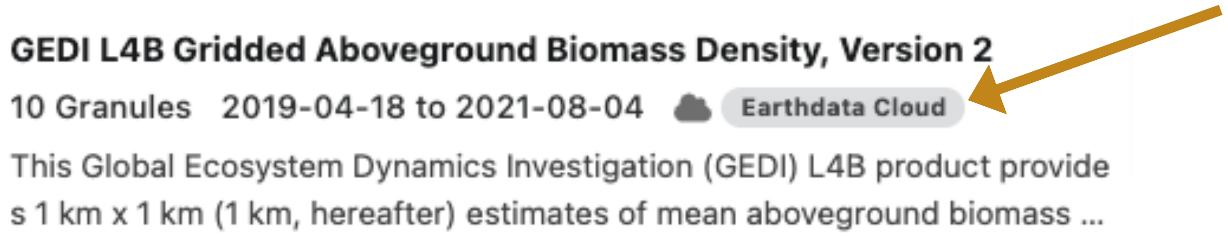
Level 1: Geolocated Waveform
Level 2: Footprint level metrics
Level 3: Gridded metrics
Level 4A: Footprint level aboveground biomass
Level 4B: Gridded aboveground biomass

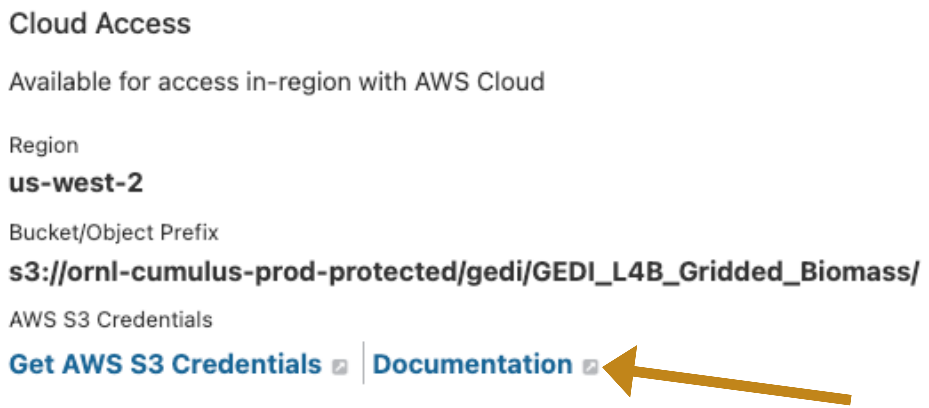
GEDI data is available through LP and ORNL DAACs

Product	Description	Archive DAAC
Level 1B	Geolocated waveform	LP DAAC
Level 2A	Elevation and height metrics	
Level 2B	Canopy cover and vertical profile metrics	
Level 3	Gridded land surface metrics	ORNL DAAC
Level 4A	Footprint level aboveground biomass density	
Level 4B	Gridded aboveground biomass density	

Earthdata Cloud: Further enabling Open Science

- NASA Earth Science Data and Services in a commercial (AWS) cloud environment
- A work in progress
- Tools for cross-DAAC access to data
  - Harmony: https://harmony.earthdata.nasa.gov/
  - OPeNDAP Hyrax: https://opendap.earthdata.nasa.gov/
  - Direct (in-region) S3 Access





Higher level GEDI data is available in multiple tools

Tool/Service	L3	L4A	L4B
Earthdata Cloud S3 access	✓	✓	✓
Earthdata Cloud OPeNDAP		✓	
Earthdata Search (Discovery)	✓	✓	✓
Common Metadata Repository API (Discovery)	✓	✓	✓
WorldView and Global Imagery Browse Services (GIBS) API	✓		**soon**
HTTPS file download	✓	✓	✓
Harmony API for subsetting		✓	
Open Geospatial Consortium Web Mapping Service (OGC WMS)	✓		✓
Open Geospatial Consortium Web Coverage Service (OGC WCS)	✓		✓
ORNL DAAC's Spatial Data Access Tool (SDAT)	✓		✓
ORNL DAAC's Shopping Cart	✓	✓	✓
ORNL DAAC's Terrestrial Ecology Subsetting & Visualization Services	✓	✓	✓
ORNL DAAC's Quick Order	✓		✓

Earthdata login (https://urs.earthdata.nasa.gov) required for all data access

L3 – Gridded (1 km) land surface metrics
L4A – Footprint level aboveground biomass
L4B – Gridded (1 km) aboveground biomass

Higher level GEDI data is available in multiple tools

Tool/Service	L3	L4A	L4B
Earthdata Cloud S3 access ←	✓	✓	✓
Earthdata Cloud OPeNDAP		✓	
Earthdata Search (Discovery)	✓	✓	✓
Common Metadata Repository API (Discovery)	✓	✓	✓
Worldview and Global Imagery Browse Services (GIBS) API	✓		**soon**
HTTPS file download	✓	✓	✓
Harmony API for subsetting ←		✓	
Open Geospatial Consortium Web Mapping Service (OGC WMS)	✓		✓
Open Geospatial Consortium Web Coverage Service (OGC WCS)	✓		✓
ORNL DAAC's Spatial Data Access Tool (SDAT)	✓		✓
ORNL DAAC's Shopping Cart	✓	✓	✓
ORNL DAAC's Terrestrial Ecology Subsetting & Visualization Services	✓	✓	✓
ORNL DAAC's Quick Order	✓		✓

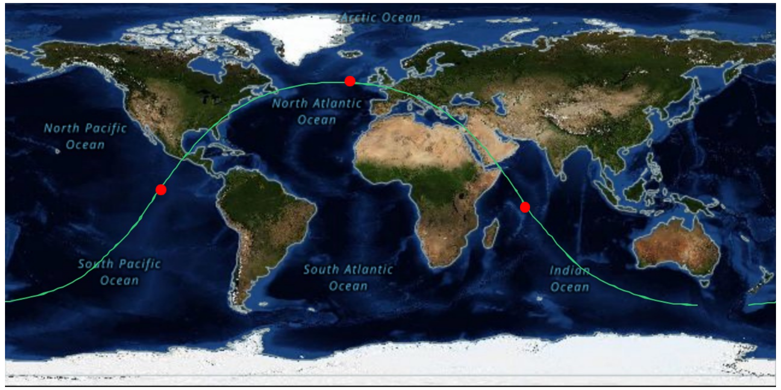
Earthdata login (https://urs.earthdata.nasa.gov) required for all data access

L3 – Gridded (1 km) land surface metrics
L4A – Footprint level aboveground biomass
L4B – Gridded (1 km) aboveground biomass

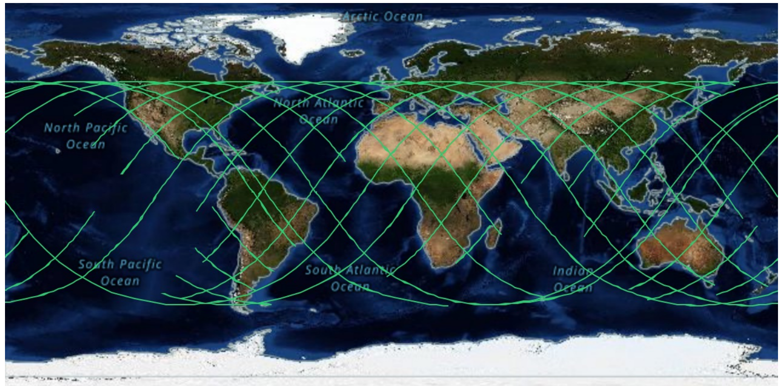
Outline

- Overview of GEDI Level 3, Level 4A and Level 4B
- Examples of accessing and using GEDI data
  - Using S3 Direct Access (Jupyter Notebook)
  - Using NASA Harmony API
    - Jupyter Notebook
    - Retrieving GEDI L4A subsets using NASA Earthdata Search

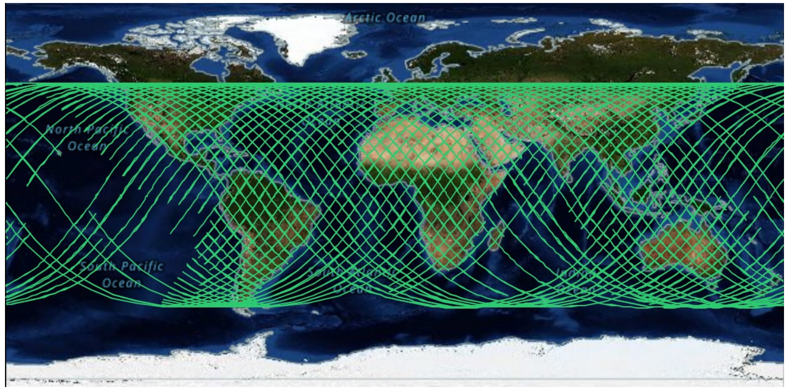
GEDI Orbits, Footprints, Grids



One GEDI orbit (orbit number 06577) (2020-02-09 15:13:21 to 16:46:15) => 4 L4A granules



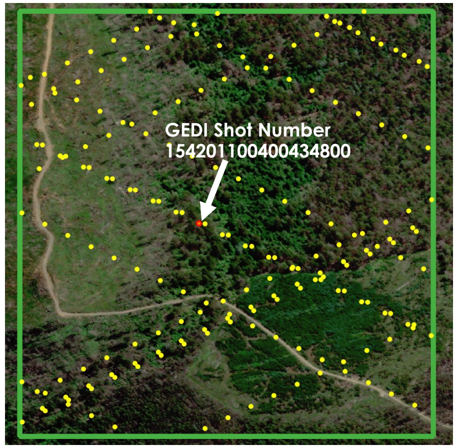
GEDI orbits over one-day (2020-02-09) => 58 L4A granules



GEDI orbits over period of one-week (2020-02-09 to 2020-02-15) => 397 L4A granules

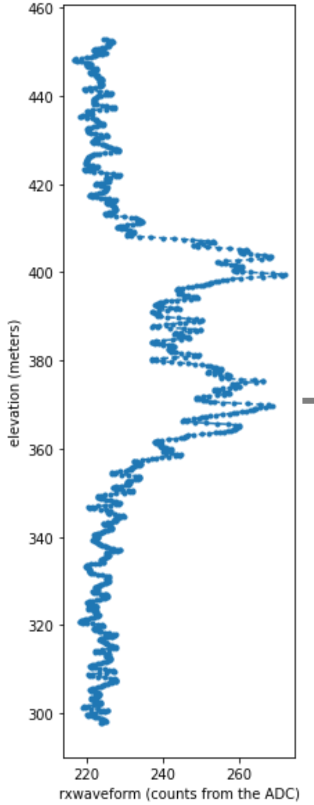
Green box = 1km x 1km EASEGRID in Tasmania, Australia. This is area where Australia's tallest trees are located

10 GEDI sub-orbits passes over the1km x 1km grid between 2019-04-17 to 2022-01-20



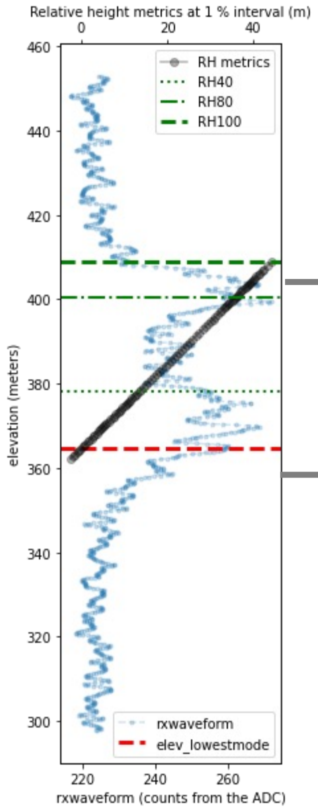
Yellow dots = GEDI shots within 1km x 1km EASEGRID (193 GEDI shots)

GEDI L3 Gridded Land Surface Metrics - Algorithm



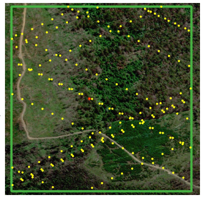
shot_number: 154201100400434800

GEDI L1B
Geolocated Waveforms
(footprint)

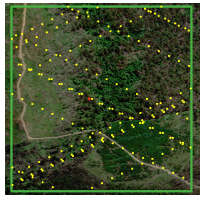


shot_number: 154201100400434800

GEDI L2A
Relative height metrics
(footprint)



RH100



elev_lowestmode

Shot Editing

L2A Variable Name	Criteria for Return Inclusion
rx_assess_quality_flag	≠ 0
surface_flag	≠ 0
stale_return_flag	= 0
rx_maxamp	> 8*sd_corrected
sensitivity	<=1 and > sensitivity_threshold
rx_algrunflag	≠ 0
Zcross	> 0
Toploc	> 0
degrade_flag	= 0

TanDEM-X

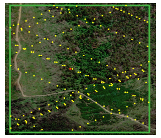
SRTM

Orbit Editing

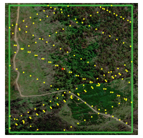
Shot Editing (2nd round)

GEDI Variable	SRTM, TDX Difference	(GEDI – TDX) Lower Bound	(GEDI – TDX) Upper Bound
Highest Return	<1.5 m	-23.3 m	57.8 m
Highest Return	>1.5 m	-38.3 m	78.7 m
Lowest Mode	<1.5 m	-41.3 m	32.8 m
Lowest Mode	>1.5 m	-56.3 m	59.5 m

Valid L2A Shots



RH100



elev_lowestmode

L3 Grids

$$\bar{x} = \frac{1}{n}\sum x_i \qquad \sigma = \sqrt{\frac{\sum(x_i-\bar{x})^2}{n}}$$

ATBD: https://daac.ornl.gov/daacdata/gedi/GEDI_L3_Land_Surface_Metrics/comp/GEDI_ATBD_L3R01.pdf

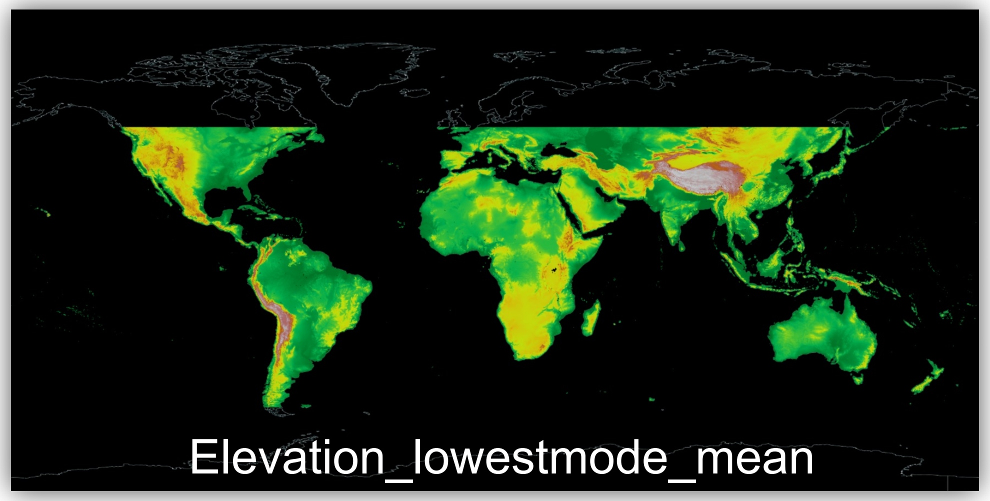
GEDI L3 Gridded Land Surface Metrics

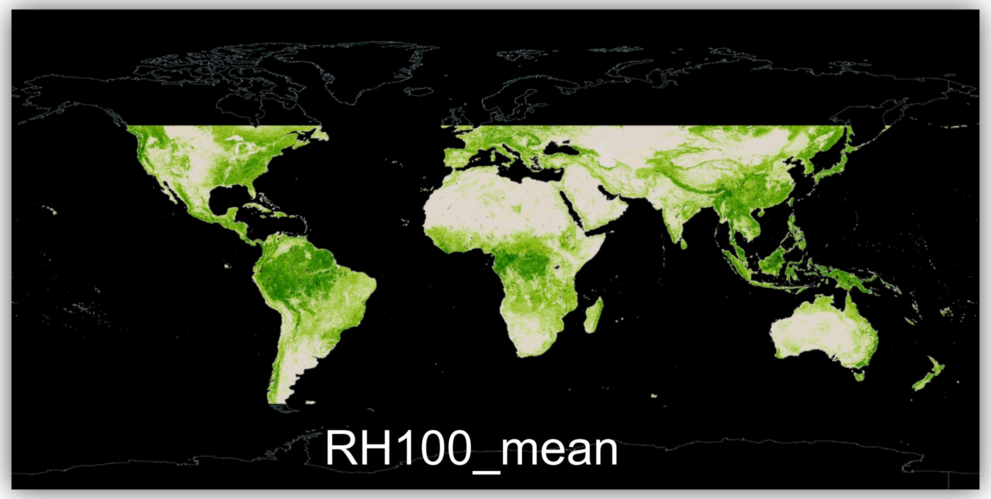
- **Data Format:** Cloud-optimized GeoTIFFs
- **Grid System:** 1km EASEGrid 2.0
- **Spatial Extent:** -52N to 52 degrees latitude
- **Temporal Extent:** Mission Weeks 19-96, 19-122, 19-138, 19-162
- **Variables:** 5 layers

DOI: https://doi.org/10.3334/ORNLDAAC/1952

GEDI L3 Gridded Land Surface Metrics - Variables

Layers	Description
Counts	Number of valid laser footprints
Elevation_lowestmode_mean	Ground elevation approximated by the mean elevation of the lowest mode of valid footprints
Elevation_lowestmode_stddev	Standard deviation of the elevation of lowest mode of valid footprints
RH100_mean	Canopy height above ground in each grid cell characterized by the mean Relative Height Metrics 100 values of valid footprints
RH100_stddev	Standard deviation of RH100 for all valid footprints

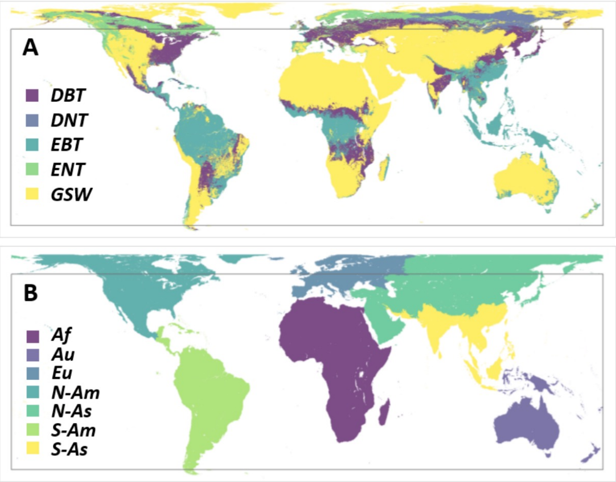

Elevation_lowestmode_mean


RH100_mean

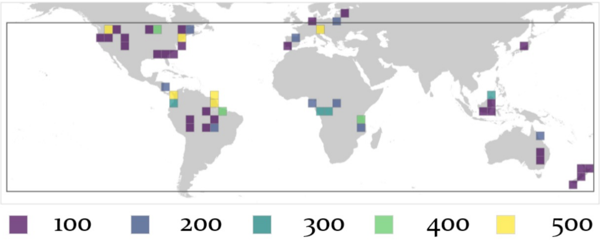
User Guide: https://daac.ornl.gov/GEDI/guides/GEDI_L3_LandSurface_Metrics_V2.html

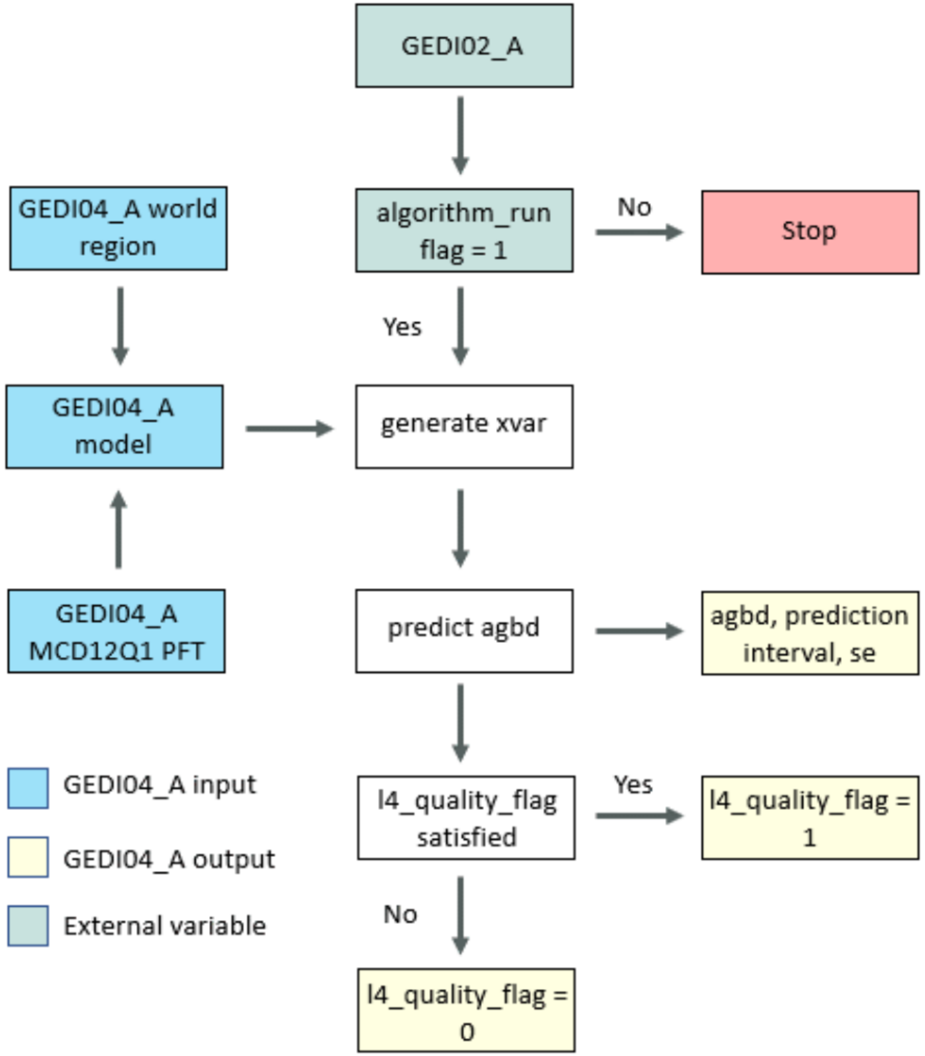
GEDI L4A Footprint Level AGBD - Algorithm

Prediction Strata



Number of simulated waveform (n=8,587)





Algorithm Setting Groups

Algorithm	Rx_processing Subgroup	Smooth width	Smoothwidth_ zcross	Front_ threshold	Back_ threshold
1	a1	6.5	6.5	3σ	6σ
2	a2	6.5	3.5	3σ	3σ
3	a3	6.5	3.5	3σ	6σ
4	a4	6.5	6.5	6σ	6σ
5	a5	6.5	3.5	3σ	2σ
6	a6	6.5	3.5	3σ	4σ

ATBD: https://daac.ornl.gov/daacdata/gedi/GEDI_L4A_AGB_Density_V2_1/comp/GEDI_ATBD_L4A_v1.0.pdf
Manuscript: Duncanson et al. https://doi.org/10.1016/j.rse.2021.112845

GEDI L4A Footprint Level AGBD

- **Data Format:** HDF5
- **Spatial Extent:** -52N to 52 degrees latitude
- **Temporal Extent:** Mission Weeks 19-138
- **Variables:** 183 variables within each of 8 beams, Ancillary and metadata information

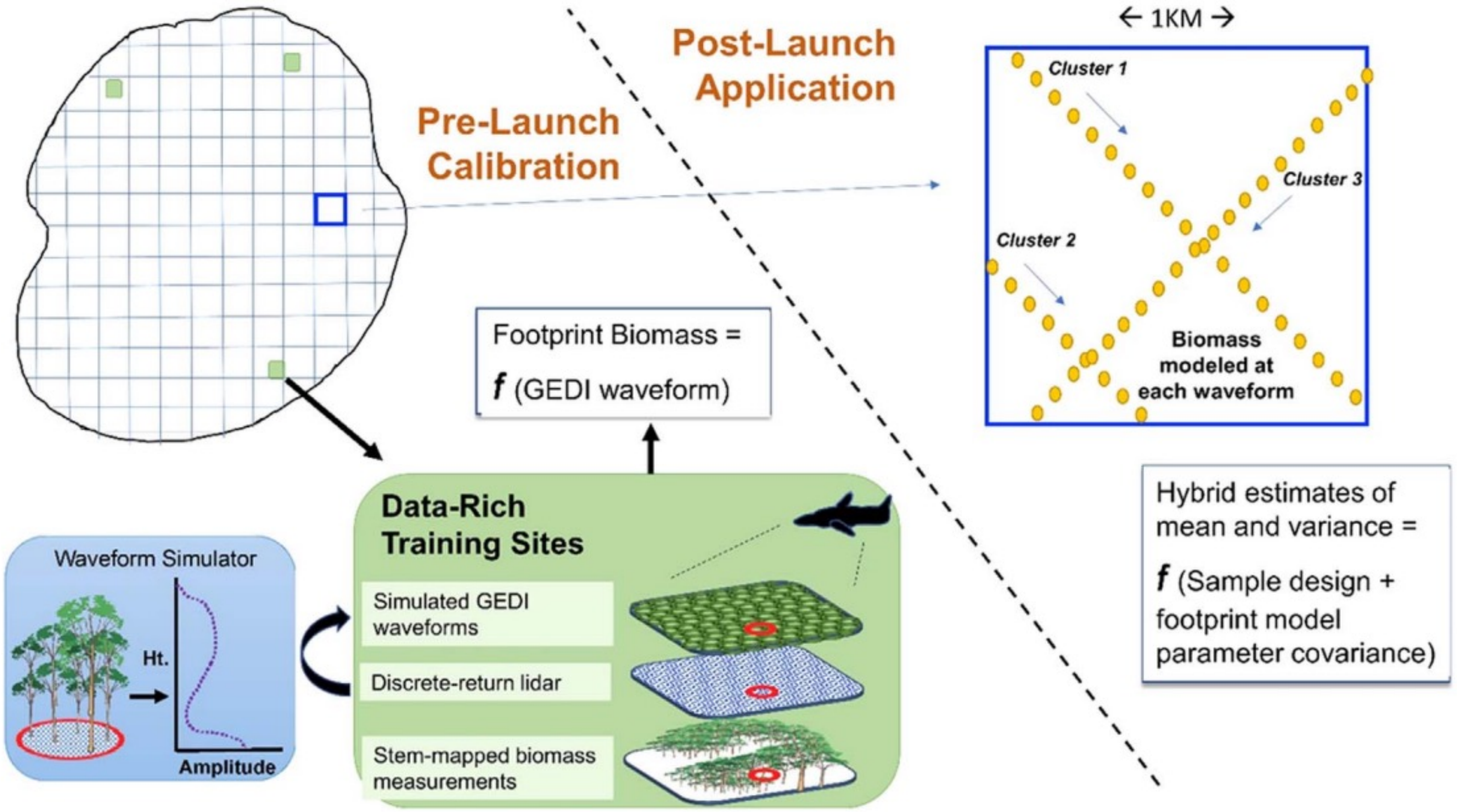
DOI: https://doi.org/10.3334/ORNLDAAC/2056

GEDI L4A Footprint Level AGBD - Variables

variable	description	units	source
agbd	Aboveground biomass density (Mg / ha)	Mg / ha	
agbd_pi_lower	Lower prediction interval (see alpha attribute for the level)	Mg / ha	
agbd_pi_upper	Upper prediction interval (see alpha attribute for the level)	Mg / ha	
agbd_se	Aboveground biomass density (Mg / ha) prediction standard error	Mg / ha	
agbd_t	Model prediction in fit units	-	
agbd_t_se	Model prediction standard error in fit units (needed for calculation of custom prediction intervals)	-	
algorithm_run_flag	The L4A algorithm is run if this flag is set to 1. This flag selects data which have sufficient waveform fidelity for AGBD estimation.	-	
l2_quality_flag	Flag identifying the most useful L2 data for biomass predictions	-	
l4_quality_flag	Flag simplifying selection of most useful biomass predictions	-	
predict_stratum	Character ID of the prediction stratum name for the 1 km cell	-	
predictor_limit_flag	Predictor value is outside the bounds of the training data (0=In bounds; 1=Lower bound; 2=Upper bound)	-	
response_limit_flag	Prediction value is outside the bounds of the training data (0=In bounds; 1=Lower bound; 2=Upper bound)	-	
xvar	Predictor variables (offset and transformation have been applied)	-	

User Guide: https://daac.ornl.gov/GEDI/guides/GEDI_L4A_AGB_Density_V2_1.html
Tutorial: https://github.com/ornldaac/gedi_tutorials/blob/main/3_gedi_l4a_exploring_data.ipynb

GEDI L4B Gridded AGBD - Algorithm

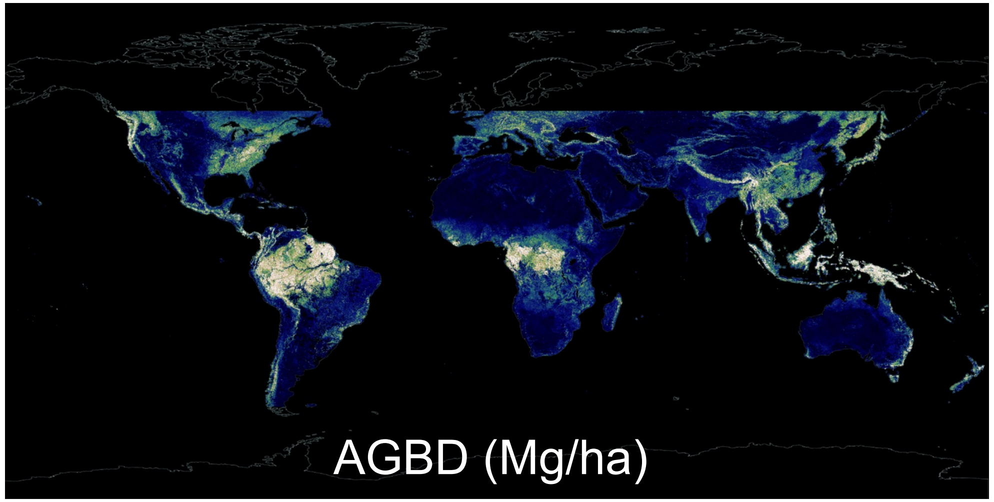


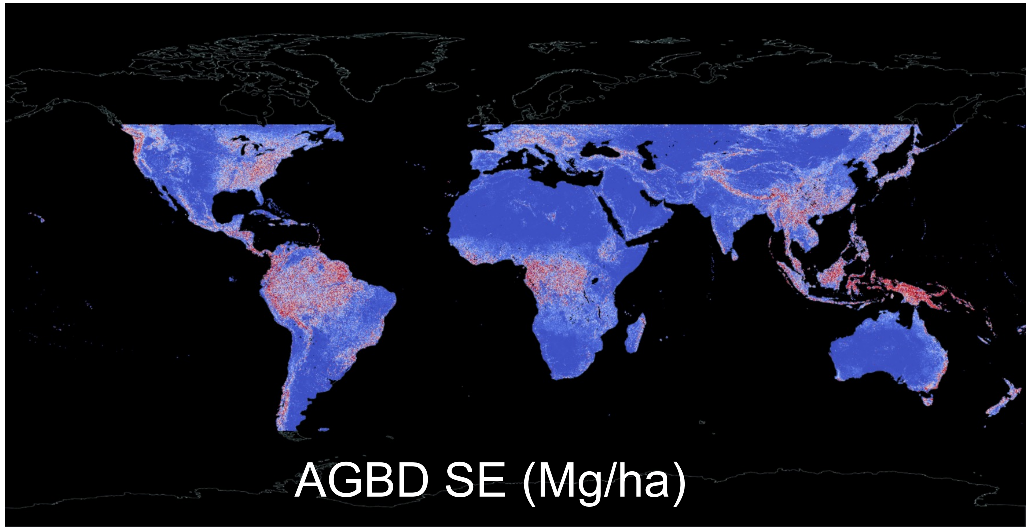
Source: Patterson et al. 2019 https://doi.org/10.1088/1748-9326/ab18df

ATBD: https://daac.ornl.gov/daacdata/gedi/GEDI_L4B_Gridded_Biomass/comp/GEDI_L4B_ATBD_v1.0.pdf
Manuscript: Dubayah et al. (in review) https://eartharxiv.org/repository/object/3278/download/6566/

GEDI L4B Gridded AGBD

- **Data Format:** Cloud-optimized GeoTIFFs
- **Grid System:** 1km EASEGrid 2.0
- **Spatial Extent:** -52N to 52 degrees latitude
- **Temporal Extent:** Mission Weeks 19-138
- **Variables:** 10 layers





DOI: https://doi.org/10.3334/ORNLDAAC/2017

GEDI L4 Gridded Land Surface Metrics - Variables

Layers	Description
Mean aboveground biomass density (MU)	Estimated mean AGBD, including forest and non-forest
Variance component 1 (V1)	Uncertainty in the estimate of mean biomass due to the field-to-GEDI model used in L4A
Variance component 2 (V2)	If Mode of Inference = 1, this is the uncertainty due to GEDI's sampling of the 1 km cell. If Mode of Inference = 2, this is uncertainty owing to the model predicting biomass
Mean aboveground biomass density standard error (SE)	Standard Error of the mean estimate, combining sampling and modeling uncertainty
Standard error as a fraction of the estimated mean AGBD (PE)	If >100%, the cell values are truncated to 100.
Number of clusters (NC)	Number of unique GEDI ground tracks with at least one high-quality waveform intersecting the grid cell
Number of samples (NS)	Total number of high-quality waveforms across all ground tracks within the grid cell
Quality flag (QF)	0=Outside the GEDI domain; 1=Land surface; 2=Land surface and meets GEDI mission L1 requirement (Percent standard error <20% or Standard Error < 20 Mg ha^{-1})
Prediction stratum (PS)	determined by plant functional type and continent. PS is associated with an L4A model parameter covariance matrix that contributes to the Model Error Variance
Mode of interference (MI)	Method used for a particular cell. Until mission completion, only those cells where hybrid inference is possible will be populated with a mean biomass value. 0=None applied; 1=Hybrid Model-Based; 2=Generalized Hierarchical Model-Based

User Guide: https://daac.ornl.gov/GEDI/guides/GEDI_L4B_Gridded_Biomass.html

Learning Resources for GEDI Products

Tutorials on GEDI Science Data Products

Author: ORNL DAAC
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Contact for the ORNL DAAC: uso@daac.ornl.gov

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Overview

These tutorials demonstrate how to discover, access and use GEDI science data products archived at the ORNL DAAC.

GEDI L4A Jupyter Notebooks

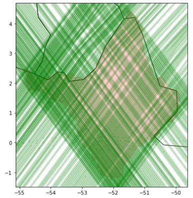
1. Searching and downloading GEDI L4A dataset (script)
2. Subsetting GEDI L4A footprints (script)
3. Exploring GEDI L4A data structure
4. Accessing GEDI L4A dataset with NASA OPeNDAP in the Cloud (script)
5. Accessing GEDI L4A dataset with NASA Harmony API
6. Reproducing L4A AGBD estimates from GEDI L2A RH metrics
7. Apply correction to AGBD estimates for selected L4A shots, Version 2

GEDI L4B Jupyter Notebooks

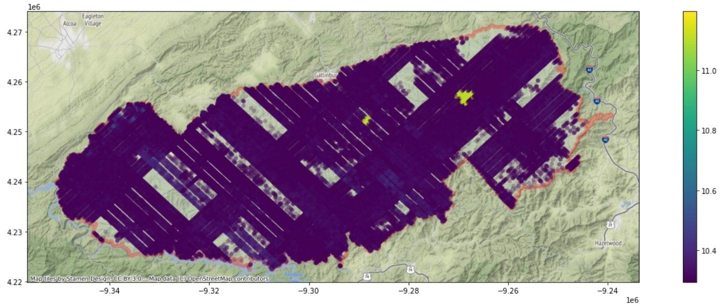
1. Access GEDI L4B Dataset with OGC Web Services

https://github.com/ornldaac/gedi_tutorials/

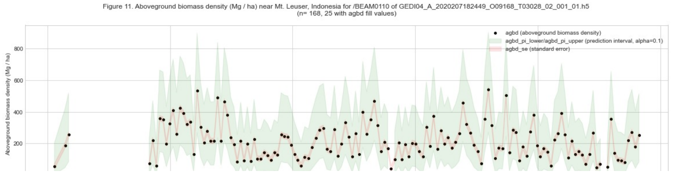
Search and Download

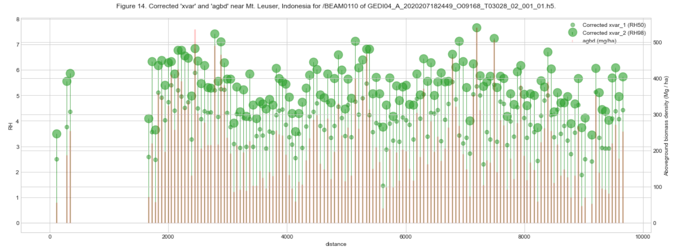


Subset



Explore





Python scripts

1. gedi_l4a_search_download.py

This script downloads GEDI L4A granules to a local directory based on GeoJSON polygon and start/end dates. First, set up NASA Earthdata Login authentication using a `.netrc` file. Please refer to the instructions here: https://wiki.earthdata.nasa.gov/display/EL/How+To+Access+Data+With+cURL+And+Wget.

usage

```
./gedi_l4a_search_download.py --doi <DOI> --date1 <start_date> --date2 <end_date> --poly <path_to_geojson_file> --outdir <
```

arguments

argument	description
--help	show help message and exit
--doi	dataset DOI e.g., 10.3334/ORNLDAAC/2056 for GEDI L4A V2.1
--date1	start date in YYYY-MM-DD format
--date2	end date in YYYY-MM-DD format
--poly	path to a GeoJSON file defining area of interest
--outdir	path to the directory for saving downloaded h5 files

example usage

```
./gedi_l4a_search_download.py --date1 2019-12-15 --date2 2020-01-12 --doi 10.3334/ORNLDAAC/2056 --poly ../polygons/amapa.j
```

2. gedi_l4a_subsets.py

This script subsets the downloaded GEDI L4A granules by a GeoJSON polygon file. The output files are in the H5 native format, with the option of converting to CSV or GeoJSON formats, and include the GEDI shots within the bounds of the polygon file.

usage

```
./gedi_l4a_subsets.py --poly <path_to_geojson_file> --indir <path_to_input_directory> --subdir <path_to_output_directory>
```

arguments

argument	description
--help	show help message and exit
--poly	path to a GeoJSON file defining area of interest
--indir	path to the directory with downloaded h5 files
--subdir	path to the directory for saving subset files
--csv	(optional) setting this creates additional output CSV subset file
--json	(optional) setting this creates additional output GeoJSON subset file

example usage

```
./gedi_l4a_subsets.py --poly ../polygons/amapa.json --indir ../full_orbits/ --subdir ../subsets/ --csv
```

3. gedi_l4a_hyrax.py

This script accesses the GEDI L4A dataset using NASA's OPeNDAP Hyrax. First, set up NASA Earthdata Login authentication using a `.netrc` file. Please refer to the instructions here: https://wiki.earthdata.nasa.gov/display/EL/How+To+Access+Data+With+cURL+And+Wget.

usage

```
./gedi_l4a_hyrax.py --doi <DOI> --date1 <start_date> --date2 <end_date> --poly <path_to_geojson_file> --beams <gedi_beams>
```

Direct S3 Access GEDI L4A from the NASA Earthdata Cloud

GEDI L4A Datasets are available through NASA's Earthdata Cloud. NASA Earthdata on Cloud is always free and accessible via either HTTPS or direct S3 bucket access. With direct S3 access, you can bring your "code to the data", making your processing faster and scalable. Direct S3 access to NASA Earthdata on Cloud is only available if your Amazon Web Services (AWS) instance is set up in the `us-west-2` region. If you are new to the Earthdata Cloud, these NASA Earthdata primers and tutorials are good resources to get you started.

To access a Juypter Notebook on AWS EC2 instance:

1. On the AWS EC2 instance, start Juypter Notebook on port 8888 with the 'no-browser' parameter: `jupyter notebook --no-browser --port=8888`
2. On your local machine, forward port 8000 to the remote port 8888 : `ssh -i my-key-pair.pem -L 8000:localhost:8888 my-instance-user-name@my-instance-IPv6-address`
3. Now, the Jupyter Notebook can be accessed at `http://localhost:8000` in your local browser.

Important: NASA Earthdata Login (EDL) is required to obtain the S3 temporary credentials and direct access S3 objects bucket. First, set up NASA Earthdata Login authentication using a `.netrc` file. Please refer to the instructions here: https://wiki.earthdata.nasa.gov/display/EL/How+To+Access+Data+With+cURL+And+Wget.

In this tutorial, we will retrieve GEDI L4A dataset from the Earthdata Cloud using direct S3 access.

https://github.com/ornldaac/gedi_tutorials/blob/main/gedi_l4a_direct_s3_access.ipynb

In [1]:

```
# import python modules
import requests
import s3fs
import h5py
import geopandas as gpd
import contextily as ctx
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from shapely.ops import orient
from IPython import display
from shapely.geometry import MultiPolygon, Polygon
from datetime import datetime
from multiprocessing import Pool
from posixpath import splitext
from os import path
import warnings
warnings.filterwarnings('ignore')
```

In [3]:

```
# installing missing modules
!pip3 install --user s3fs
```

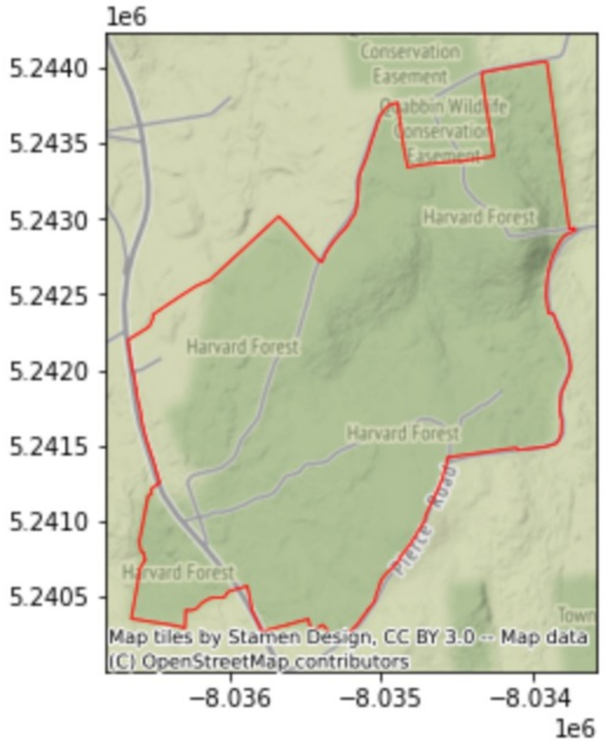
```
Requirement already satisfied: s3fs in ./.local/lib/python3.8/site-packages (2022.5.0)
```

We will read an area within the Harvard Forests as a GeoJSON file. The Harvard Forests is one of the most extensively studied ecological sites in the United States.

If an area of interest is already defined as a polygon, the polygon file (geojson, shapefile, or kml) can be used to find overlapping GEDI L4A files. More details about this capability are described on this page.

In [2]:
```
# read geojson
harvard = gpd.read_file("polygons/harvard.json")
# orient
harvard.geometry = harvard.geometry.apply(orient, args=(1,))

ax=harvard.to_crs(epsg=3857).plot(figsize=(5, 5), edgecolor='red', facecolor='none')
ctx.add_basemap(ax, zoom = 14)
```



Let's define a function that searches NASA's Common Metadata Repository (CMR) API to search and find the granules.

In [3]:
```
def search_cmr(doi: str, geojson):
    # CMR API base url
    cmrurl='https://cmr.earthdata.nasa.gov/search/'
    # doi search to get concept_id
    doisearch = f'{cmrurl}collections.json?doi={doi}'
    concept_id = requests.get(doisearch).json()['feed']['entry'][0]['id']

    page_num = 1
    page_size = 2000 # CMR page size limit
    s3_arr = []

    while True:
         # defining parameters
        cmr_param = {
            "collection_concept_id": concept_id,
            "page_size": page_size,
            "page_num": page_num,
            "simplify-shapefile": 'true' # this is needed to bypass 5000 coordinates limit of CMR
        }

        granulesearch = f'{cmrurl}granules.json'
        r = requests.post(granulesearch, data=cmr_param, files=geojson)
        r.raise_for_status()
        granules = r.json()['feed']['entry']
        if granules:
            for g in granules:
                # Get s3 links
                for links in g['links']:
                    if links['href'].startswith('s3://'):
                        s3_arr.append(links['href'])

            page_num += 1
        else:
            break

    return s3_arr
```

In [4]:
```
doi = '10.3334/ORNLDAAC/2056'# GEDI L4A DOI
geojson = {"shapefile": ("harvard.geojson", harvard.geometry.to_json(), "application/geo+json")}

granule_arr = search_cmr(doi, geojson)
```

The `granule_arr` contains a list of `s3` granule links, starting with `s3://`. We can print the first two items of the `granule_arr`.

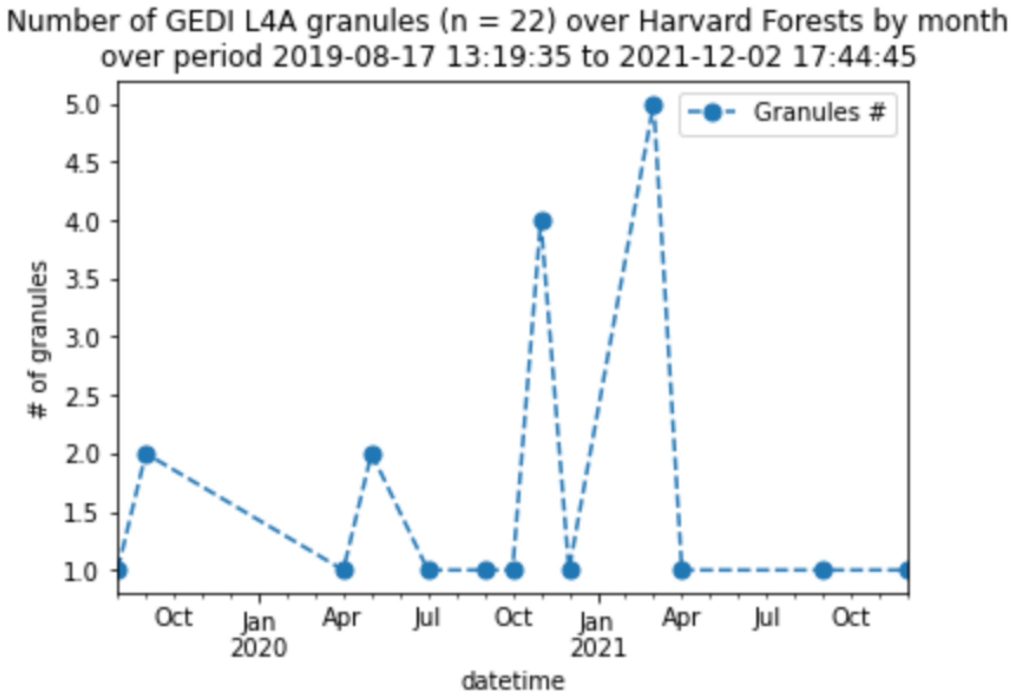
In [5]:
```
granule_arr = sorted(granule_arr)
granule_arr[:2]
```

Out[5]:
```
['s3://ornl-cumulus-prod-protected/gedi/GEDI_L4A_AGB_Density_V2_1/data/GEDI04_A_2019229131935_O03846_02_T03642_02_002_02_V002.h5',
 's3://ornl-cumulus-prod-protected/gedi/GEDI_L4A_AGB_Density_V2_1/data/GEDI04_A_2019246121050_O04109_03_T04380_02_002_02_V002.h5']
```

In [6]:
```python
fmt = '%Y%j%H%M%S' # GEDI granule name has date time as YYYYDDDHHMMSS
granule_dt = [g.split('/')[-1].split('_')[2] for g in granule_arr]
df = pd.DataFrame(list(zip(granule_dt, granule_arr)), columns =['datetime', 'Granules #'])

df['datetime'] = pd.to_datetime(df['datetime'], format=fmt)
df.set_index('datetime', inplace=True)

# plotting a monthly granule count plot
title = f'''Number of GEDI L4A granules (n = {len(granule_arr)}) over Harvard Forests by month
over period {df.index.min()} to {df.index.max()} '''
ax = df.groupby(df.index.to_period('M')).agg('count').plot(style='o--', markersize=7, title=title)
ax.set_ylabel("# of granules")
plt.show()
```



A temporary S3 Credentials is needed for read-only, same-region, direct access to S3 objects on the Earthdata cloud. Each of the DAACs has its own endpoint. More information about S3 credentials for ORNL DAAC is available at: https://data.ornldaac.earthdata.nasa.gov/s3credentialsREADME.

We will now retrieve the credentials for ORNL DAAC for GEDI L4A access. These credentials are temporary and currently valid for one hour.

In [7]:
```
# python function to get s3 credentials
def get_s3credentials(daac: str):
    # DAAC S3 Credentials Endpoint
    earthadata_s3 = f"https://data.{daac}.earthdata.nasa.gov/s3credentials"
    r = requests.get(earthadata_s3)
    r.raise_for_status()
    return r.json()

# get s3 credentials
s3credentials = get_s3credentials("ornldaac")
# print expiration datetime
print(f'The S3 credentials will expire on {s3credentials["expiration"]} UTC')
```

```
The S3 credentials will expire on 2022-06-14 20:28:08+00:00 UTC
```

We will use [S3Fs](), Pythonic file interface to S3 for file-system style access. Alternatively, you can use [Boto3](), AWS Software Development Kit (SDK) for Python. We will pass S3 credentials to S3Fs class `S3FileSystem`.

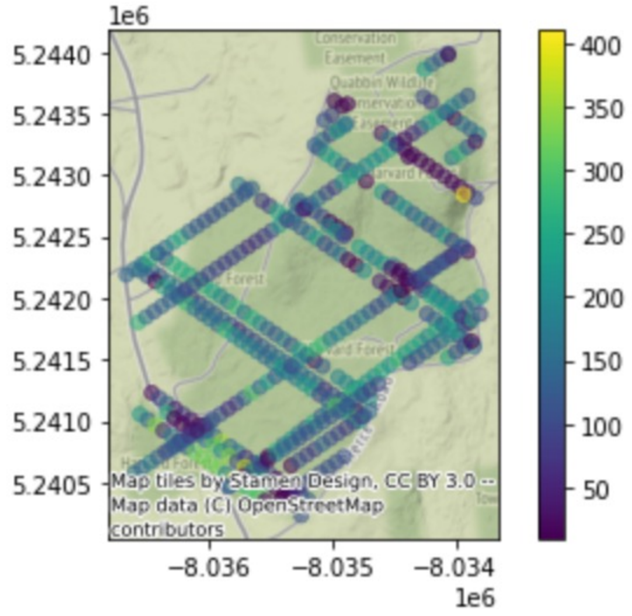
In [8]:
```
fs_s3 = s3fs.S3FileSystem(anon=False,
                          key=s3credentials['accessKeyId'],
                          secret=s3credentials['secretAccessKey'],
                          token=s3credentials['sessionToken'])
```

In [11]:
```
# setting header variables
headers = ['lat_lowestmode', 'lon_lowestmode', 'elev_lowestmode', 'shot_number']
variables = ['agbd', 'l4_quality_flag']
headers.extend(variables)
# outfiles
outfiles = []
for s3_url in granule_arr:
    with fs_s3.open(s3_url, mode='rb') as fh:
        with h5py.File(fh) as hf:
            print(f"Downloading {s3_url}")
            out_csv = splitext(path.basename(s3_url))[0] + '.csv'
            outfiles.append(out_csv)
            with open(out_csv, "w") as f:
                f.write(','.join(headers)+'\n')
            for var in list(hf.keys()):
                if var.startswith('BEAM'):
                    lat = hf[var]['lat_lowestmode']
                    lon = hf[var]['lon_lowestmode']
                    df = pd.DataFrame({'lat_lowestmode': lat, 'lon_lowestmode': lon})
                    gdf = gpd.GeoDataFrame(df, geometry=gpd.points_from_xy(df.lon_lowestmode, df.lat_lowestmode))
                    gdf_harvd = gdf[gdf['geometry'].within(harvard.geometry[0])]
                    if not gdf_harvd.empty:
                        for v in headers[2:]:
                            gdf_harvd[v] = None
                        # 3. retrieving variables of interest, agbd, l4_quality_flag in this case.
                        # We are only retriving the shots within subset area.
                        for _, df_gr in gdf_harvd.groupby((gdf_harvd.index.to_series().diff() > 1).cumsum()):
                            i = df_gr.index.min()
                            j = df_gr.index.max()
                            for v in headers[2:]:
                                gdf_harvd.loc[i:j, (v)] = hf[var][v][i:j+1]

                        # saving the output file
                        gdf_harvd[gdf_harvd['agbd'] != -9999].to_csv(out_csv, mode='a', index=False,
                                                                        header=False, columns=headers)
```

```
Downloading s3://ornl-cumulus-prod-protected/gedi/GEDI_L4A_AGB_Density_V2_1/data/GEDI04_A_2019229131935_O03846_02_T03
642_02_002_02_V002.h5
```

In [12]:
```
l4a_df = pd.concat(pd.read_csv(f,header=0) for f in outfiles)
l4a_gdf = gpd.GeoDataFrame(l4a_df, geometry=gpd.points_from_xy(l4a_df.lon_lowestmode, l4a_df.lat_lowestmode))
l4a_gdf['agbd'] = l4a_gdf['agbd'].astype(float)
l4a_gdf.crs="EPSG:4326"
ax4=l4a_gdf.to_crs(epsg=3857).plot( column='agbd', alpha=0.5,legend=True)
ctx.add_basemap(ax4, zoom=14)
```



Accessing GEDI L4A variables using NASA Harmony API

NASA's Harmony Services allows seamless access and production of analysis-ready Earth observation data across different DAACs, by enabling cloud-based spatial, temporal, and variable subsetting and data conversions. The Global Ecosystem Dynamics Investigation (GEDI) L4A Footprint Level Aboveground Biomass Density (AGBD) is available from NASA Harmony API.

This tutorial demonstrates how to directly access and subset the GEDI L4A variables using Harmony API for an area in NASA's Delta-X project. The Delta-X project collects field and airborne measurements of ecological and hydrology variables over the two river basins (Atchafalaya and Terrebonne) in the Mississippi River Delta of the United States. The subset of the GEDI L4A dataset for the Delta-X area can enable a comparison of aboveground biomass between GEDI L4A and the field measurements.

While NASA's Harmony services are available directly through RESTful API, we will use Harmony-Py Python library for this tutorial. Harmony-Py provides a friendly interface for integrating with NASA's Harmony Services.

In [1]:
```
# import python modules
import h5py
import requests as re
import pandas as pd
import geopandas as gpd
import contextily as ctx
import matplotlib.pyplot as plt
from datetime import datetime
from glob import glob
from harmony import BBox, Client, Collection, Environment, Request
```

https://github.com/ornldaac/gedi_tutorials/blob/main/gedi_l4a_harmony.ipynb

NASA Harmony API requires [NASA Earthdata Login (EDL)](). You can set up NASA Earthdata Login authentication using a `.netrc` file. Please refer to the instructions here: https://wiki.earthdata.nasa.gov/display/EL/How+To+Access+Data+With+cURL+And+Wget. Alternatively, you can also login to harmony_client directly by passing EDL authentication as the following in the Jupyter Notebook itself:

```
harmony_client = Client(auth=("your EDL username", "your EDL password"))
```

First, we create a Harmony Client object. If you are passing the EDL authentication, please do as shown above with `auth` parameter.

In [2]:
```
harmony_client = Client()
```

Now let's retrieve the `Concept ID` of the GEDI L4A dataset. The `Concept ID` is NASA Earthdata's unique ID for its dataset.

In [3]:
```
# GEDI L4A DOI
doi = '10.3334/ORNLDAAC/2056'

# CMR API base url
doisearch=f'https://cmr.earthdata.nasa.gov/search/collections.json?doi={doi}'
concept_id = re.get(doisearch).json()['feed']['entry'][0]['id']
concept_id
```

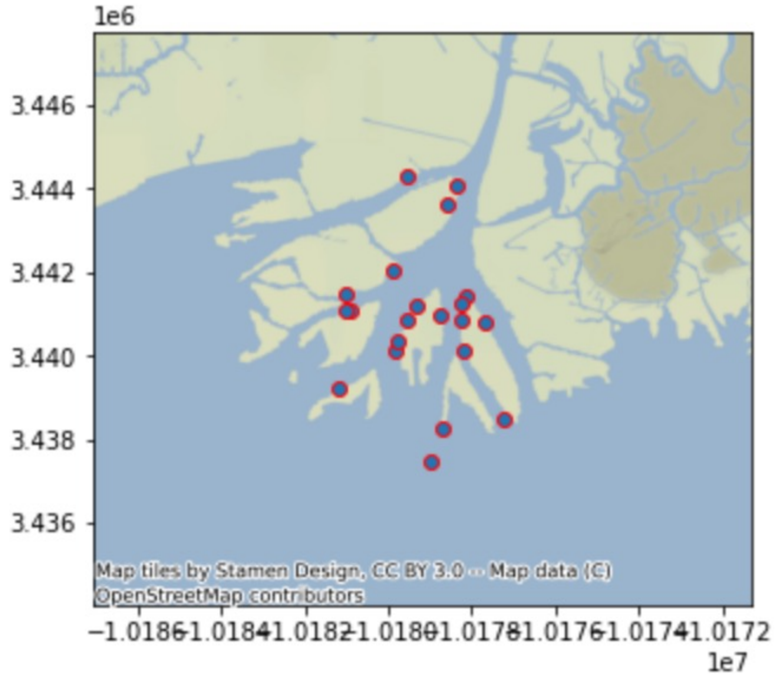
Out[3]:
```
'C2237824918-ORNL_CLOUD'
```

Let's create a Harmony Collection object with the concept_id retrieved above. We will also define the GEDI L4A variables of interest and temporal range.

In [4]:
```
collection = Collection(id=concept_id)
variables = ['/BEAM0101/agbd',
             '/BEAM0101/l4_quality_flag',
             '/BEAM0101/shot_number',
             '/BEAM0101/delta_time',
             '/BEAM0101/lat_lowestmode',
             '/BEAM0101/lon_lowestmode']
temporal_range = {'start': datetime(2019, 4, 1),
                  'stop': datetime(2020, 5, 31)}
```

We will use the spatial extent of a [Pre-DeltaX Vegetation Structure dataset](). The location and aboveground biomass of the *Salix nigra* plots collected in the Spring of 2015 are provided as a GeoJSON file at `/polygons/atchafalaya_salix_spring15.json`. Let's open this file and compute its bound.

In [5]:
```
salix = gpd.read_file("polygons/atchafalaya_salix_spring15.json")
b = salix.total_bounds
# bounding box for Harmony
bounding_box = BBox(w=b[0], s=b[1], e=b[2], n=b[3])
# map of Salix plots
ax=salix.to_crs(epsg=3857).plot(figsize=(5, 5), edgecolor='red')
plt.margins(y=0.5, x=1.5)
ctx.add_basemap(ax, zoom = 13)
```



Now we can create a Harmony request with variables, temporal range, and bounding box and submit the request using the Harmony client object. We will use the `download_all` method, which uses a multithreaded downloader and returns a concurrent future. Futures are asynchronous and let us use the downloaded file as soon as the download is complete while other files are still being downloaded.

In [6]:
```
request = Request(collection=collection,
                  variables=variables,
                  temporal=temporal_range,
                  spatial=bounding_box)

# submit harmony request, will return job id
subset_job_id = harmony_client.submit(request)

print(f'Processing job: {subset_job_id}')

print(f'Waiting for the job to finish')
results = harmony_client.result_json(subset_job_id, show_progress=True)

print(f'Downloading subset files...')
futures = harmony_client.download_all(subset_job_id, overwrite=False)
for f in futures:
    # all subsetted files have this suffix
    if f.result().endswith('subsetted.h5'):
        print(f'Downloaded: {f.result()}')

print(f'Done downloading files.')
```

```
Processing job: f5c642bd-4295-4a3c-96fc-35b00c6ed560
Waiting for the job to finish
```

```
 [ Processing: 100% ] |###################################################| [|]
```

```
Downloading subset files...
Downloaded: GEDI04_A_2020102150820_O07538_02_T04606_02_002_02_V002_subsetted.h5
Downloaded: GEDI04_A_2020126054750_O07904_02_T00337_02_002_02_V002_subsetted.h5
Downloaded: GEDI04_A_2019200010439_O03388_02_T00337_02_002_02_V002_subsetted.h5
Downloaded: GEDI04_A_2019148212155_O02594_02_T04606_02_002_02_V002_subsetted.h5
Done downloading files.
```

All the subsetted files are saved as `_subsetted.h5`. Let's open these `h5` files and plot the `agbd` value in a map.

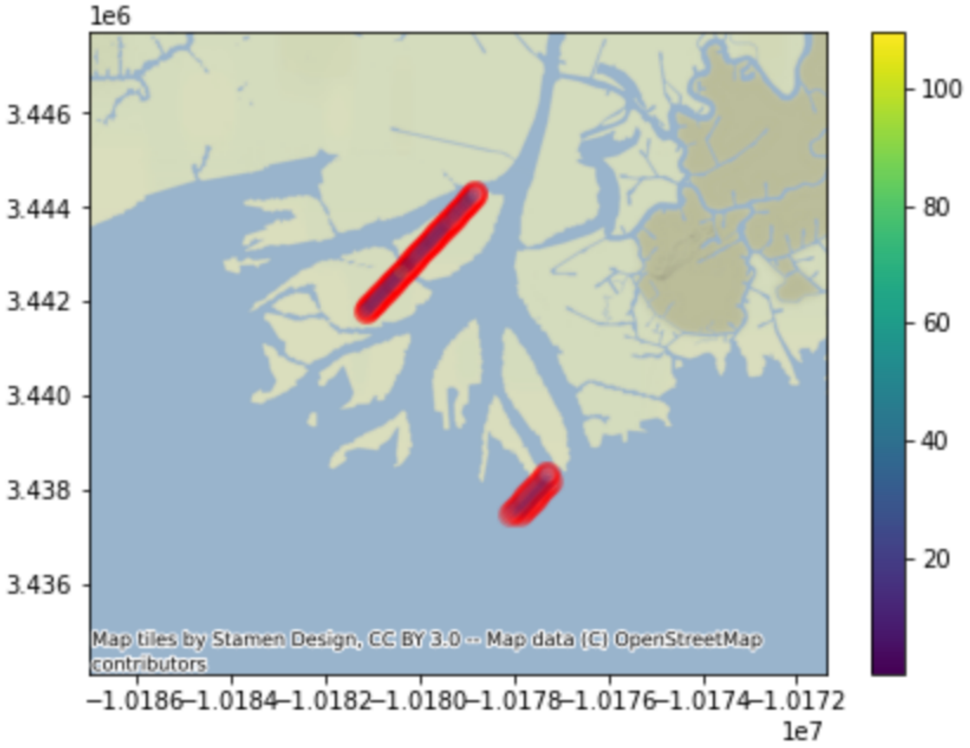
In [8]:
```
subset_df = pd.DataFrame()
for subfile in glob('*_subsetted.h5'):
    hf_in = h5py.File(subfile, 'r')
    beam = hf_in['BEAM0101']
    col_names = []
    col_val = []
    # read all variables
    for key, value in beam.items():
        col_names.append(key)
        col_val.append(value[:].tolist())

    # Appending to the subset_df dataframe
    beam_df = pd.DataFrame(map(list, zip(*col_val)), columns=col_names)
    subset_df = pd.concat([subset_df, beam_df])
    hf_in.close()
# print head of dataframe
subset_df.head()
```

Out[8]:

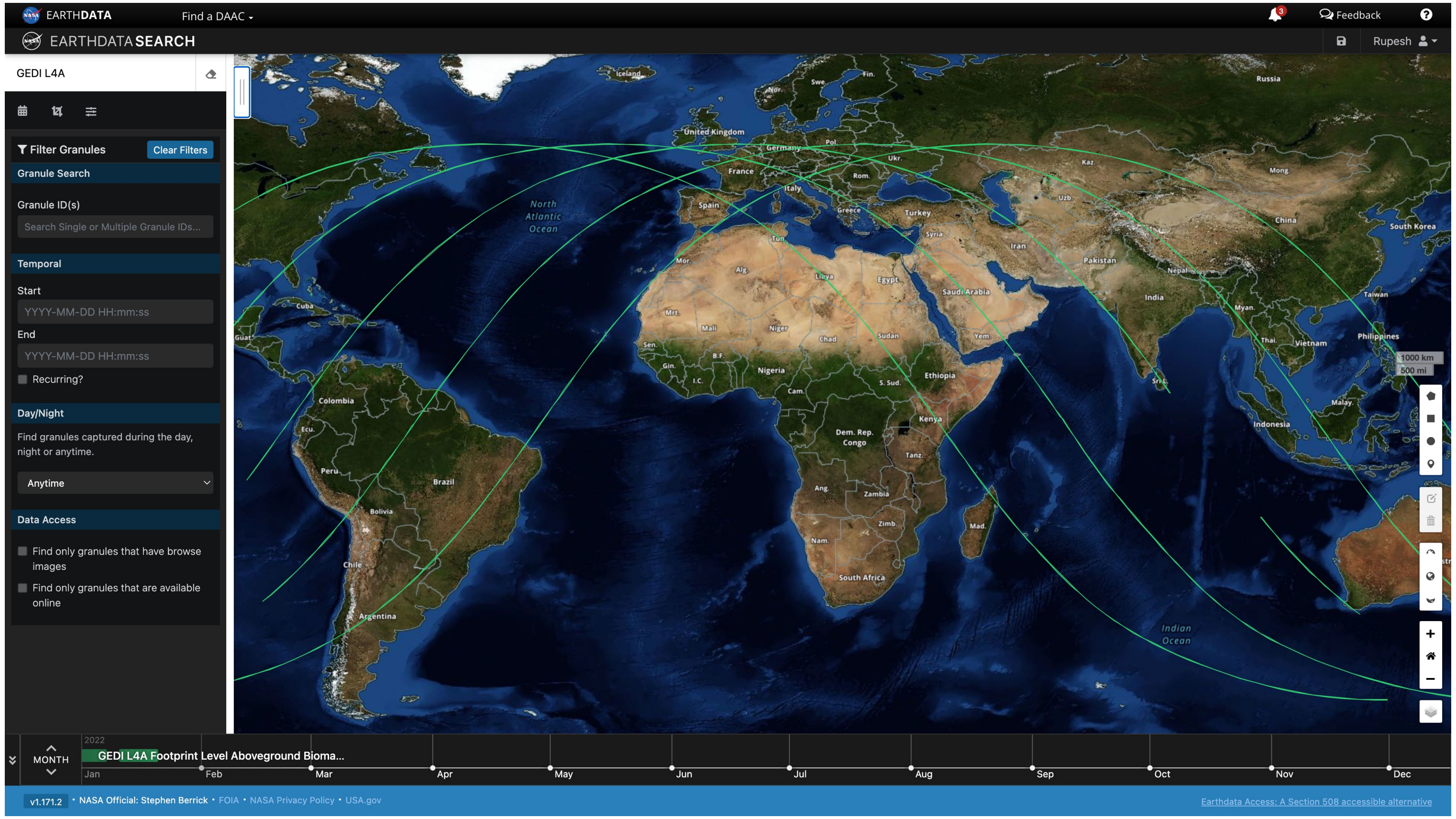
	agbd	delta_time	l4_quality_flag	lat_lowestmode	lon_lowestmode	shot_number
0	10.014098	7.185488e+07	0	29.518411	-91.458868	75380500200240320
1	10.500650	7.185488e+07	0	29.518788	-91.458466	75380500200240321
2	11.524564	7.185488e+07	0	29.519165	-91.458064	75380500200240322
3	10.356710	7.185488e+07	0	29.519541	-91.457662	75380500200240323
4	10.417495	7.185488e+07	0	29.519918	-91.457260	75380500200240324

In [9]:
```
gdf = gpd.GeoDataFrame(subset_df, geometry=gpd.points_from_xy(subset_df.lon_lowestmode, subset_df.lat_lowestmode))
gdf.crs="EPSG:4326"
gdf_epsg3857 = gdf.to_crs(epsg=3857)
ax1=gdf_epsg3857.plot(color='white', edgecolor='red', alpha=0.3, linewidth=5, figsize=(7, 5))
gdf_epsg3857[gdf_epsg3857['agbd'] != -9999][:-1].plot(ax=ax1, column='agbd', alpha=0.1, linewidth=0, legend=True)
plt.margins(y=0.5, x=1.5)
ctx.add_basemap(ax1, zoom=13)
```

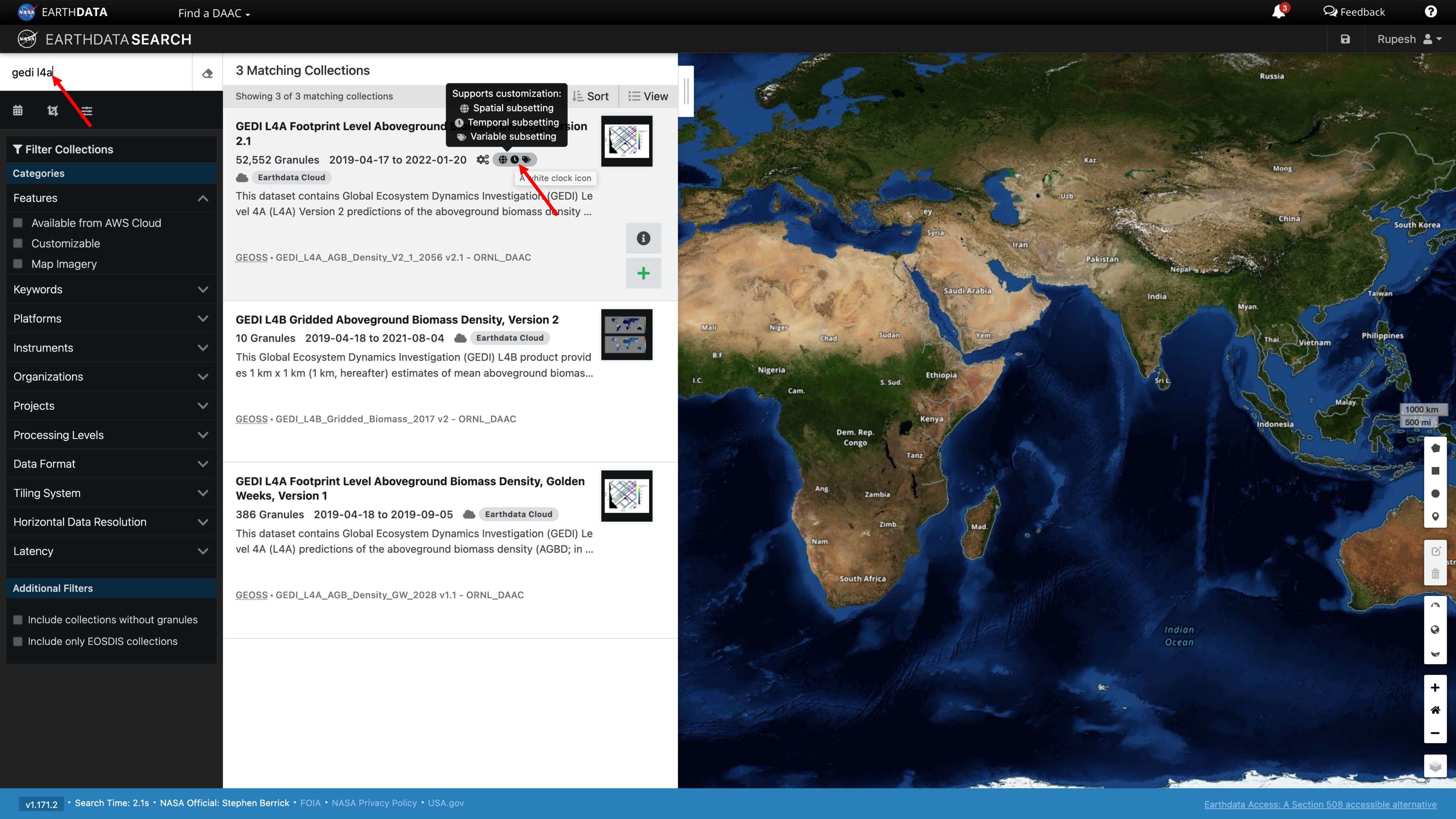


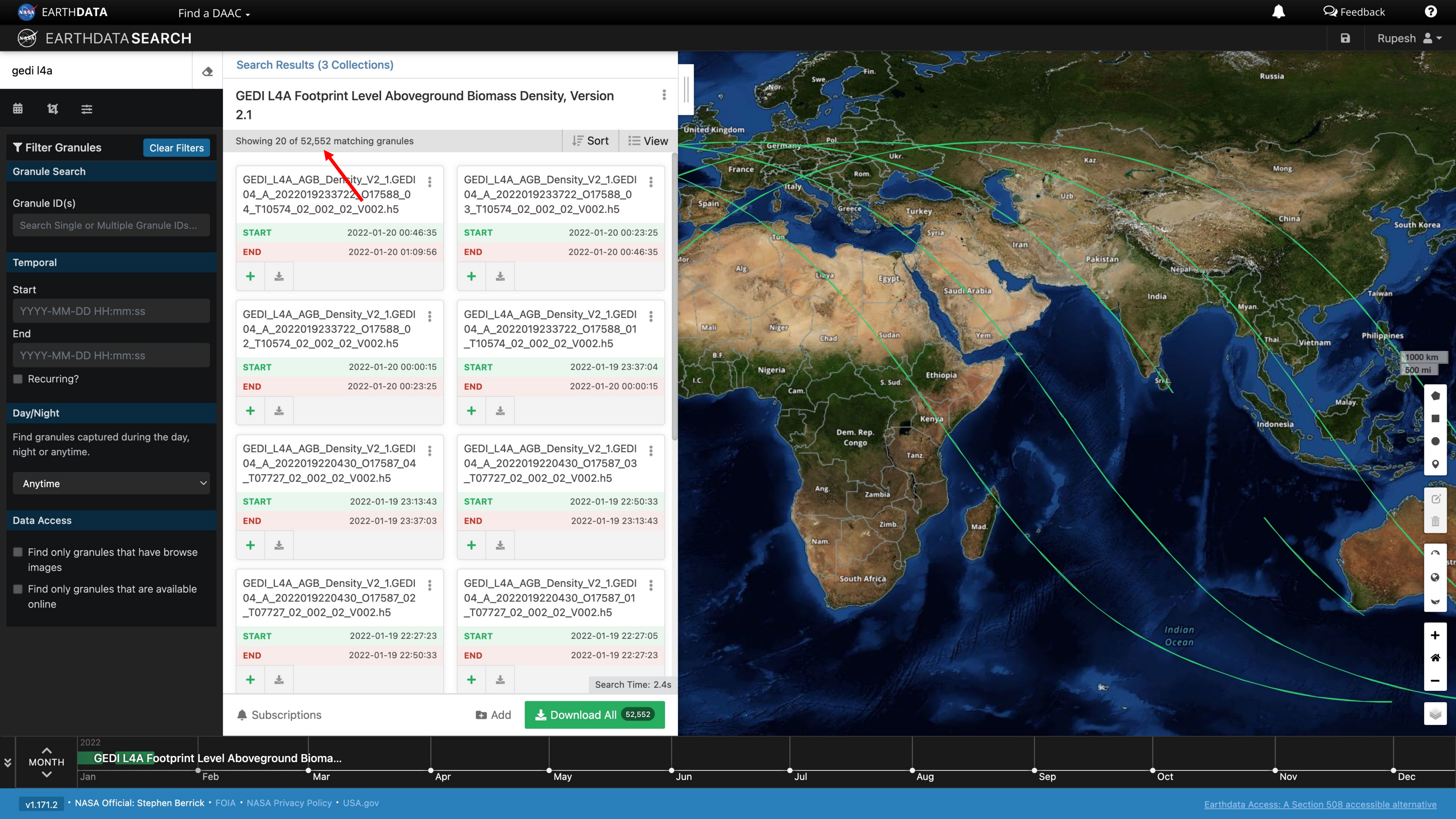
Now that we have GEDI data downloaded, can you compare the aboveground estimates of GEDI L4B with that of the [Pre-DeltaX vegetation dataset]?

Using NASA Earthdata Search and Harmony to Subset GEDI L4A



https://search.earthdata.nasa.gov/


EARTHDATA
Find a DAAC
3
Feedback
EARTHDATA SEARCH
Rupesh
gedi l4a
3 Matching Collections
Showing 3 of 3 matching collections
Supports customization:
Spatial subsetting
Temporal subsetting
Variable subsetting
Sort
View
Filter Collections
Categories
Features
Available from AWS Cloud
Customizable
Map Imagery
Keywords
Platforms
Instruments
Organizations
Projects
Processing Levels
Data Format
Tiling System
Horizontal Data Resolution
Latency
Additional Filters
Include collections without granules
Include only EOSDIS collections
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
52,552 Granules 2019-04-17 to 2022-01-20
A white clock icon
Earthdata Cloud
This dataset contains Global Ecosystem Dynamics Investigation (GEDI) Level 4A (L4A) Version 2 predictions of the aboveground biomass density ...
GEOSS • GEDI_L4A_AGB_Density_V2_1_2056 v2.1 - ORNL_DAAC
GEDI L4B Gridded Aboveground Biomass Density, Version 2
10 Granules 2019-04-18 to 2021-08-04
Earthdata Cloud
This Global Ecosystem Dynamics Investigation (GEDI) L4B product provides 1 km x 1 km (1 km, hereafter) estimates of mean aboveground biomas...
GEOSS • GEDI_L4B_Gridded_Biomass_2017 v2 - ORNL_DAAC
GEDI L4A Footprint Level Aboveground Biomass Density, Golden Weeks, Version 1
386 Granules 2019-04-18 to 2019-09-05
Earthdata Cloud
This dataset contains Global Ecosystem Dynamics Investigation (GEDI) Level 4A (L4A) predictions of the aboveground biomass density (AGBD; in ...
GEOSS • GEDI_L4A_AGB_Density_GW_2028 v1.1 - ORNL_DAAC
1000 km
500 mi
Indian Ocean
v1.171.2 • Search Time: 2.1s • NASA Official: Stephen Berrick • FOIA • NASA Privacy Policy • USA.gov
Earthdata Access: A Section 508 accessible alternative


EARTHDATA
Find a DAAC
Feedback
EARTHDATA SEARCH
Rupesh
gedi l4a
Filter Granules
Clear Filters
Granule Search
Granule ID(s)
Search Single or Multiple Granule IDs...
Temporal
Start
YYYY-MM-DD HH:mm:ss
End
YYYY-MM-DD HH:mm:ss
Recurring?
Day/Night
Find granules captured during the day, night or anytime.
Anytime
Data Access
Find only granules that have browse images
Find only granules that are available online
Search Results (3 Collections)
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
Showing 20 of 52,552 matching granules
Sort
View
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2022019233722_O17588_04_T10574_02_002_02_V002.h5
START 2022-01-20 00:46:35
END 2022-01-20 01:09:56
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2022019233722_O17588_03_T10574_02_002_02_V002.h5
START 2022-01-20 00:23:25
END 2022-01-20 00:46:35
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2022019233722_O17588_02_T10574_02_002_02_V002.h5
START 2022-01-20 00:00:15
END 2022-01-20 00:23:25
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2022019233722_O17588_01_T10574_02_002_02_V002.h5
START 2022-01-19 23:37:04
END 2022-01-20 00:00:15
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2022019220430_O17587_04_T07727_02_002_02_V002.h5
START 2022-01-19 23:13:43
END 2022-01-19 23:37:03
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2022019220430_O17587_03_T07727_02_002_02_V002.h5
START 2022-01-19 22:50:33
END 2022-01-19 23:13:43
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2022019220430_O17587_02_T07727_02_002_02_V002.h5
START 2022-01-19 22:27:23
END 2022-01-19 22:50:33
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2022019220430_O17587_01_T07727_02_002_02_V002.h5
START 2022-01-19 22:27:05
END 2022-01-19 22:27:23
Search Time: 2.4s
Subscriptions
Add
Download All 52,552
2022
MONTH
GEDI L4A Footprint Level Aboveground Bioma...
Jan
Feb
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Nov
Dec
1000 km
500 mi
v1.171.2
NASA Official: Stephen Berrick
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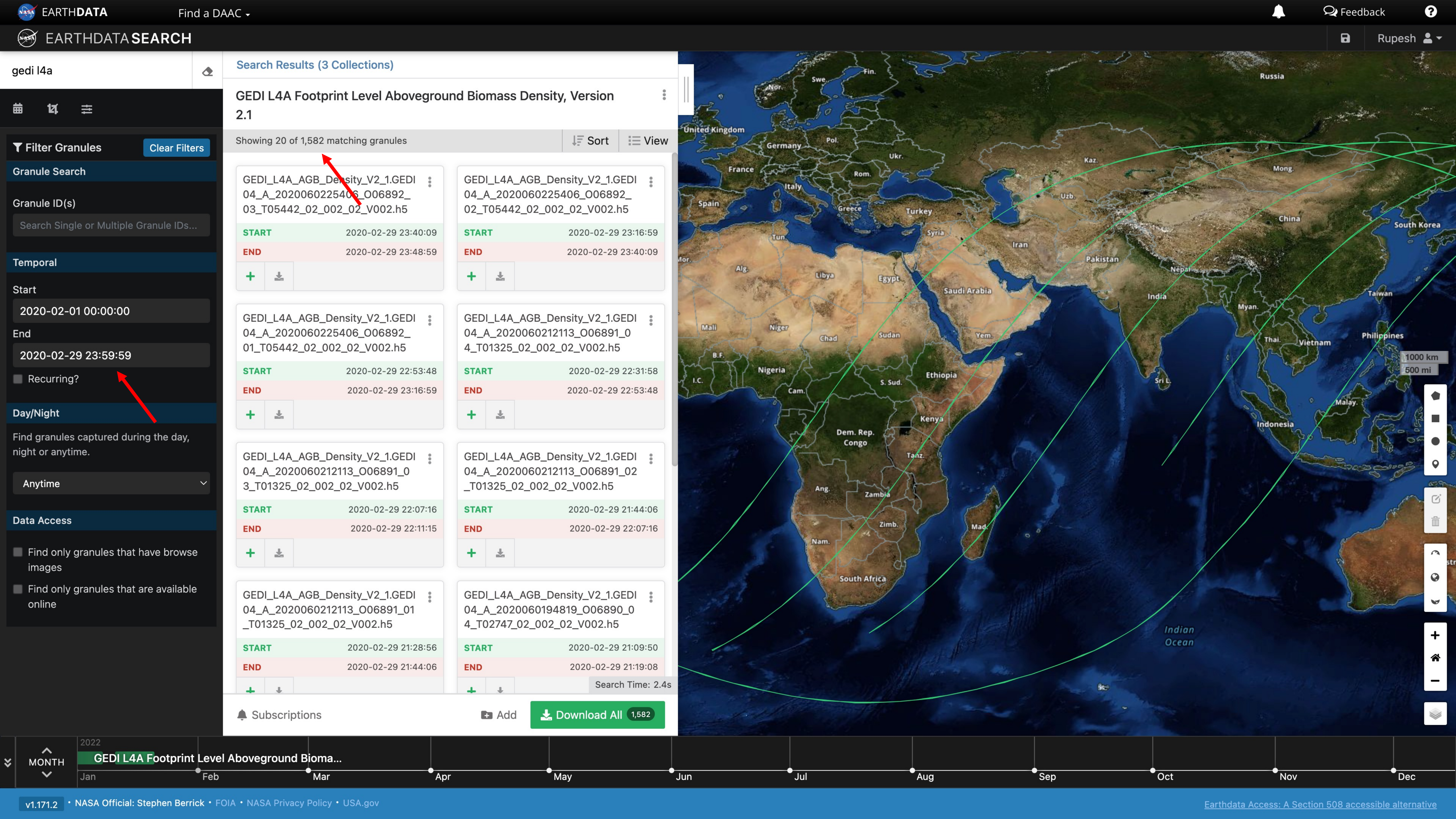
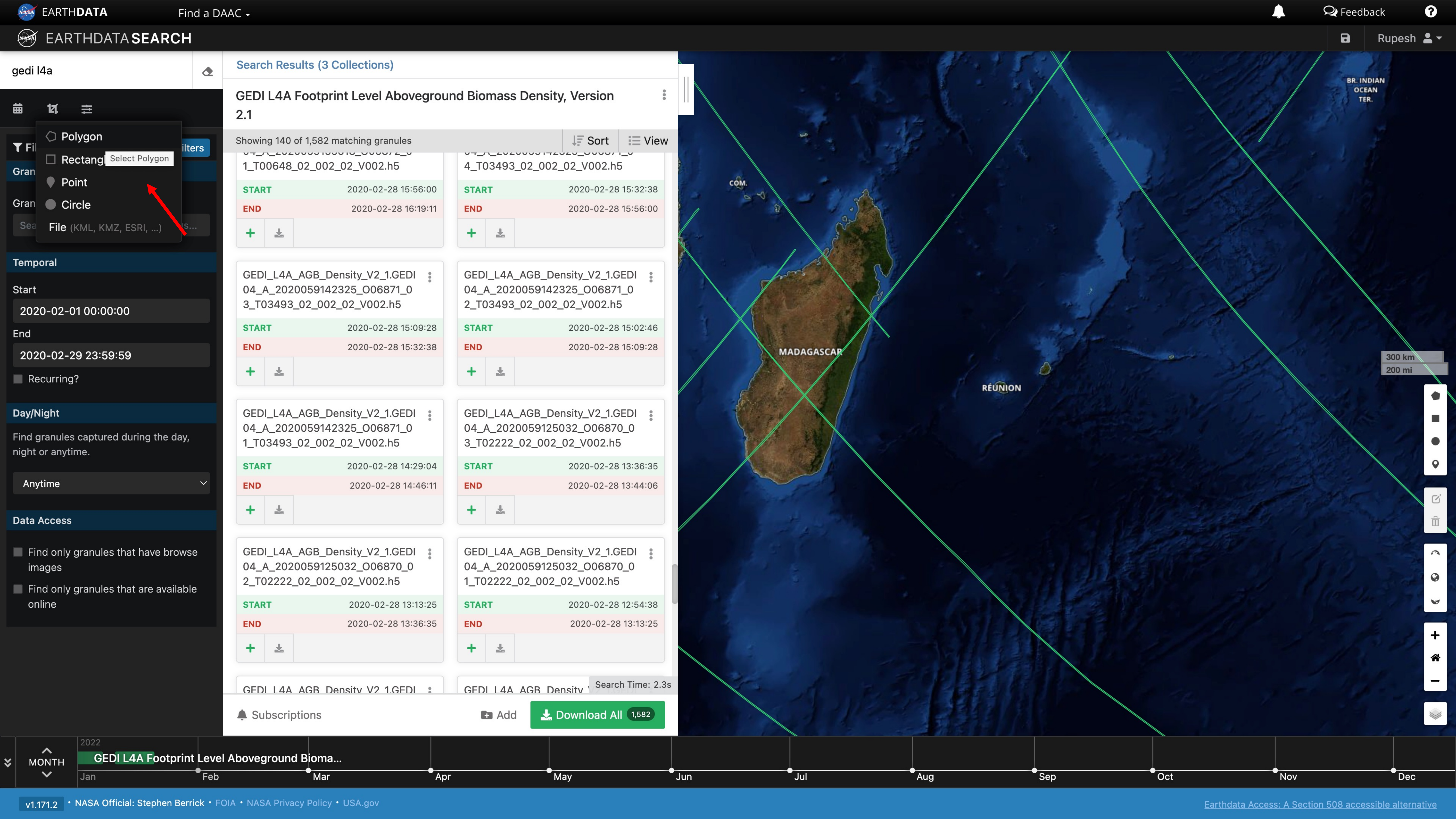
NASA Privacy Policy
USA.gov
Earthdata Access: A Section 508 accessible alternative


EARTHDATA
Find a DAAC
Feedback
EARTHDATA SEARCH
Rupesh
gedi l4a
Search Results (3 Collections)
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
Showing 20 of 1,582 matching granules
Sort
View
Filter Granules
Clear Filters
Granule Search
Granule ID(s)
Search Single or Multiple Granule IDs...
Temporal
Start
2020-02-01 00:00:00
End
2020-02-29 23:59:59
Recurring?
Day/Night
Find granules captured during the day, night or anytime.
Anytime
Data Access
Find only granules that have browse images
Find only granules that are available online
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020060225406_O06892_03_T05442_02_002_02_V002.h5
START 2020-02-29 23:40:09
END 2020-02-29 23:48:59
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020060225406_O06892_02_T05442_02_002_02_V002.h5
START 2020-02-29 23:16:59
END 2020-02-29 23:40:09
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020060225406_O06892_01_T05442_02_002_02_V002.h5
START 2020-02-29 22:53:48
END 2020-02-29 23:16:59
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020060212113_O06891_04_T01325_02_002_02_V002.h5
START 2020-02-29 22:31:58
END 2020-02-29 22:53:48
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020060212113_O06891_03_T01325_02_002_02_V002.h5
START 2020-02-29 22:07:16
END 2020-02-29 22:11:15
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020060212113_O06891_02_T01325_02_002_02_V002.h5
START 2020-02-29 21:44:06
END 2020-02-29 22:07:16
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020060212113_O06891_01_T01325_02_002_02_V002.h5
START 2020-02-29 21:28:56
END 2020-02-29 21:44:06
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020060194819_O06890_04_T02747_02_002_02_V002.h5
START 2020-02-29 21:09:50
END 2020-02-29 21:19:08
Search Time: 2.4s
Subscriptions
Add
Download All 1,582
1000 km
500 mi
2022
MONTH
GEDI L4A Footprint Level Aboveground Bioma...
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
v1.171.2 • NASA Official: Stephen Berrick • FOIA • NASA Privacy Policy • USA.gov
Earthdata Access: A Section 508 accessible alternative


EARTHDATA
Find a DAAC
Feedback
EARTHDATA SEARCH
Rupesh
gedi l4a
Polygon
Rectang
Select Polygon
Point
Circle
File (KML, KMZ, ESRI, ...)
Temporal
Start
2020-02-01 00:00:00
End
2020-02-29 23:59:59
Recurring?
Day/Night
Find granules captured during the day, night or anytime.
Anytime
Data Access
Find only granules that have browse images
Find only granules that are available online
Search Results (3 Collections)
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
Showing 140 of 1,582 matching granules
Sort
View
1_T00648_02_002_02_V002.h5
START 2020-02-28 15:56:00
END 2020-02-28 16:19:11
4_T03493_02_002_02_V002.h5
START 2020-02-28 15:32:38
END 2020-02-28 15:56:00
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020059142325_O06871_03_T03493_02_002_02_V002.h5
START 2020-02-28 15:09:28
END 2020-02-28 15:32:38
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020059142325_O06871_02_T03493_02_002_02_V002.h5
START 2020-02-28 15:02:46
END 2020-02-28 15:09:28
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020059142325_O06871_01_T03493_02_002_02_V002.h5
START 2020-02-28 14:29:04
END 2020-02-28 14:46:11
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020059125032_O06870_03_T02222_02_002_02_V002.h5
START 2020-02-28 13:36:35
END 2020-02-28 13:44:06
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020059125032_O06870_02_T02222_02_002_02_V002.h5
START 2020-02-28 13:13:25
END 2020-02-28 13:36:35
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020059125032_O06870_01_T02222_02_002_02_V002.h5
START 2020-02-28 12:54:38
END 2020-02-28 13:13:25
Search Time: 2.3s
Subscriptions
Add
Download All 1,582
COM.
MADAGASCAR
RÉUNION
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GEDI L4A Footprint Level Aboveground Bioma...
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
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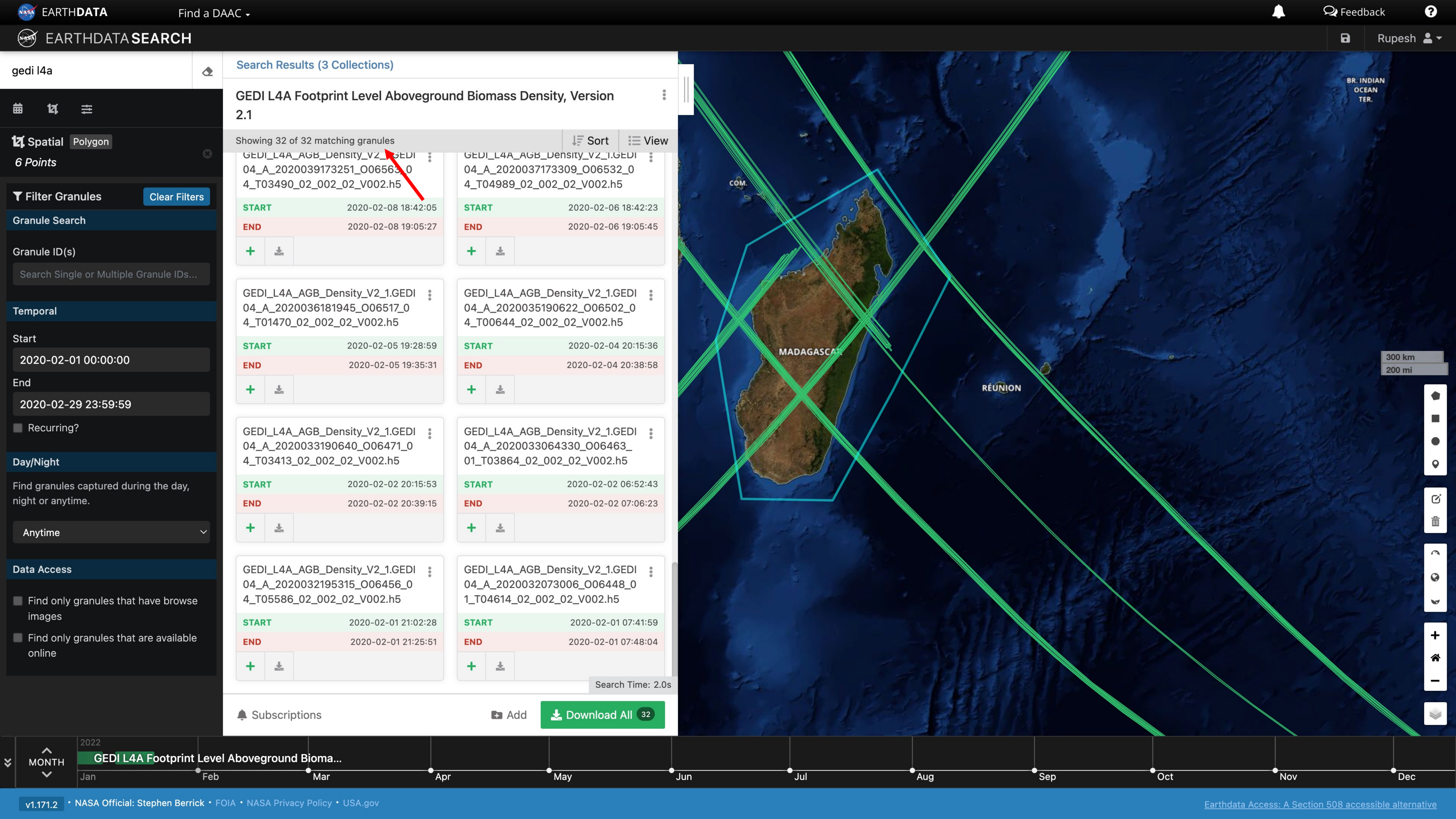
EARTHDATA
Find a DAAC
Feedback
EARTHDATA SEARCH
Rupesh
gedi l4a
Search Results (3 Collections)
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
Showing 32 of 32 matching granules
Sort
View
Spatial Polygon
6 Points
Filter Granules
Clear Filters
Granule Search
Granule ID(s)
Search Single or Multiple Granule IDs...
Temporal
Start
2020-02-01 00:00:00
End
2020-02-29 23:59:59
Recurring?
Day/Night
Find granules captured during the day, night or anytime.
Anytime
Data Access
Find only granules that have browse images
Find only granules that are available online
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020039173251_O06563_04_T03490_02_002_02_V002.h5
START 2020-02-08 18:42:05
END 2020-02-08 19:05:27
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020037173309_O06532_04_T04989_02_002_02_V002.h5
START 2020-02-06 18:42:23
END 2020-02-06 19:05:45
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020036181945_O06517_04_T01470_02_002_02_V002.h5
START 2020-02-05 19:28:59
END 2020-02-05 19:35:31
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020035190622_O06502_04_T00644_02_002_02_V002.h5
START 2020-02-04 20:15:36
END 2020-02-04 20:38:58
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020033190640_O06471_04_T03413_02_002_02_V002.h5
START 2020-02-02 20:15:53
END 2020-02-02 20:39:15
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020033064330_O06463_01_T03864_02_002_02_V002.h5
START 2020-02-02 06:52:43
END 2020-02-02 07:06:23
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020032195315_O06456_04_T05586_02_002_02_V002.h5
START 2020-02-01 21:02:28
END 2020-02-01 21:25:51
GEDI_L4A_AGB_Density_V2_1.GEDI04_A_2020032073006_O06448_01_T04614_02_002_02_V002.h5
START 2020-02-01 07:41:59
END 2020-02-01 07:48:04
Search Time: 2.0s
Subscriptions
Add
Download All 32
BR. INDIAN OCEAN TER.
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MADAGASCAR
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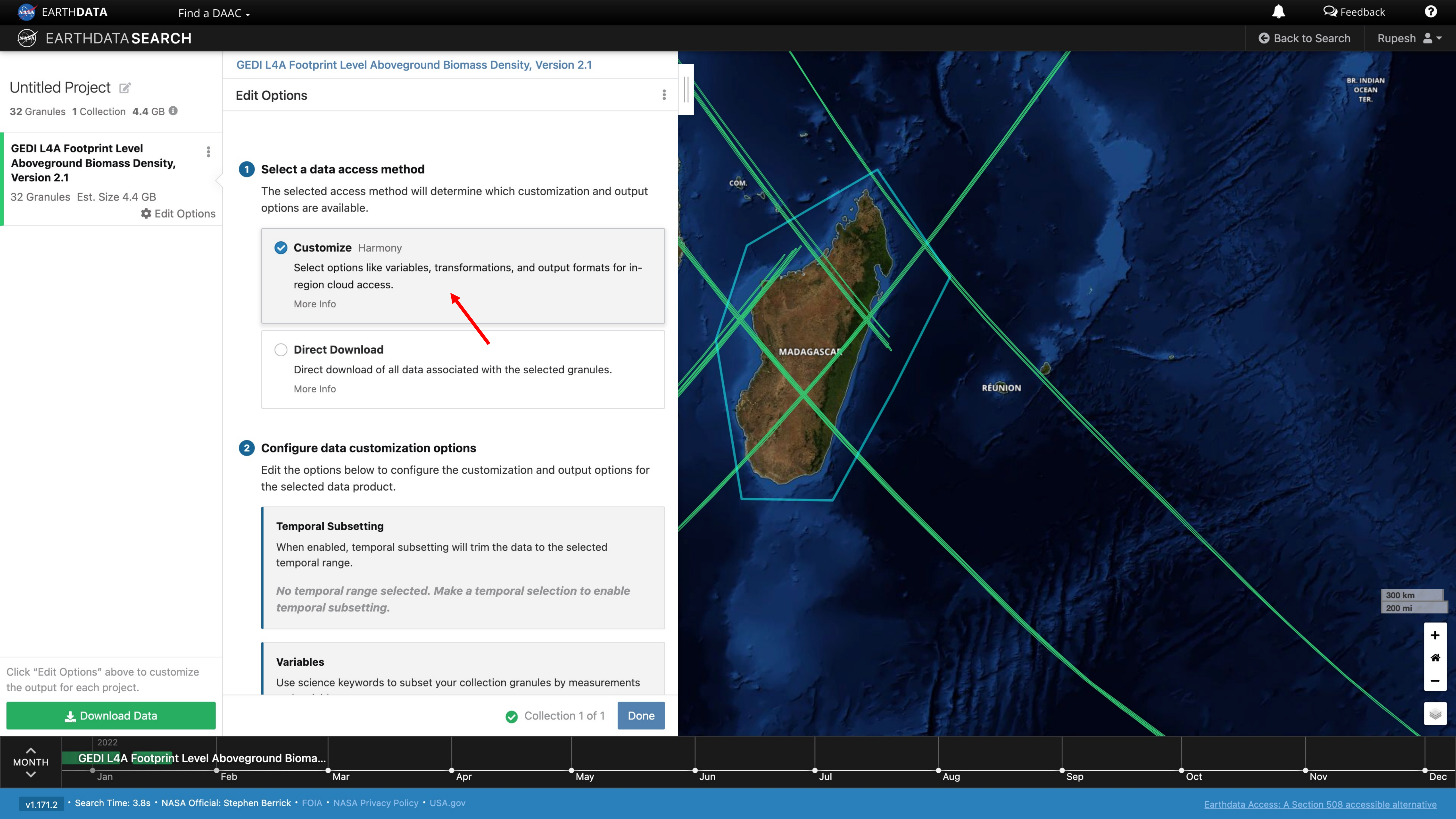
EARTHDATA
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EARTHDATA SEARCH
Back to Search
Rupesh
Untitled Project
32 Granules 1 Collection 4.4 GB
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
32 Granules Est. Size 4.4 GB
Edit Options
Click "Edit Options" above to customize the output for each project.
Download Data
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
Edit Options
1 Select a data access method
The selected access method will determine which customization and output options are available.
Customize Harmony
Select options like variables, transformations, and output formats for in-region cloud access.
More Info
Direct Download
Direct download of all data associated with the selected granules.
More Info
2 Configure data customization options
Edit the options below to configure the customization and output options for the selected data product.
Temporal Subsetting
When enabled, temporal subsetting will trim the data to the selected temporal range.
No temporal range selected. Make a temporal selection to enable temporal subsetting.
Variables
Use science keywords to subset your collection granules by measurements
Collection 1 of 1
Done
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Search Time: 3.8s
NASA Official: Stephen Berrick
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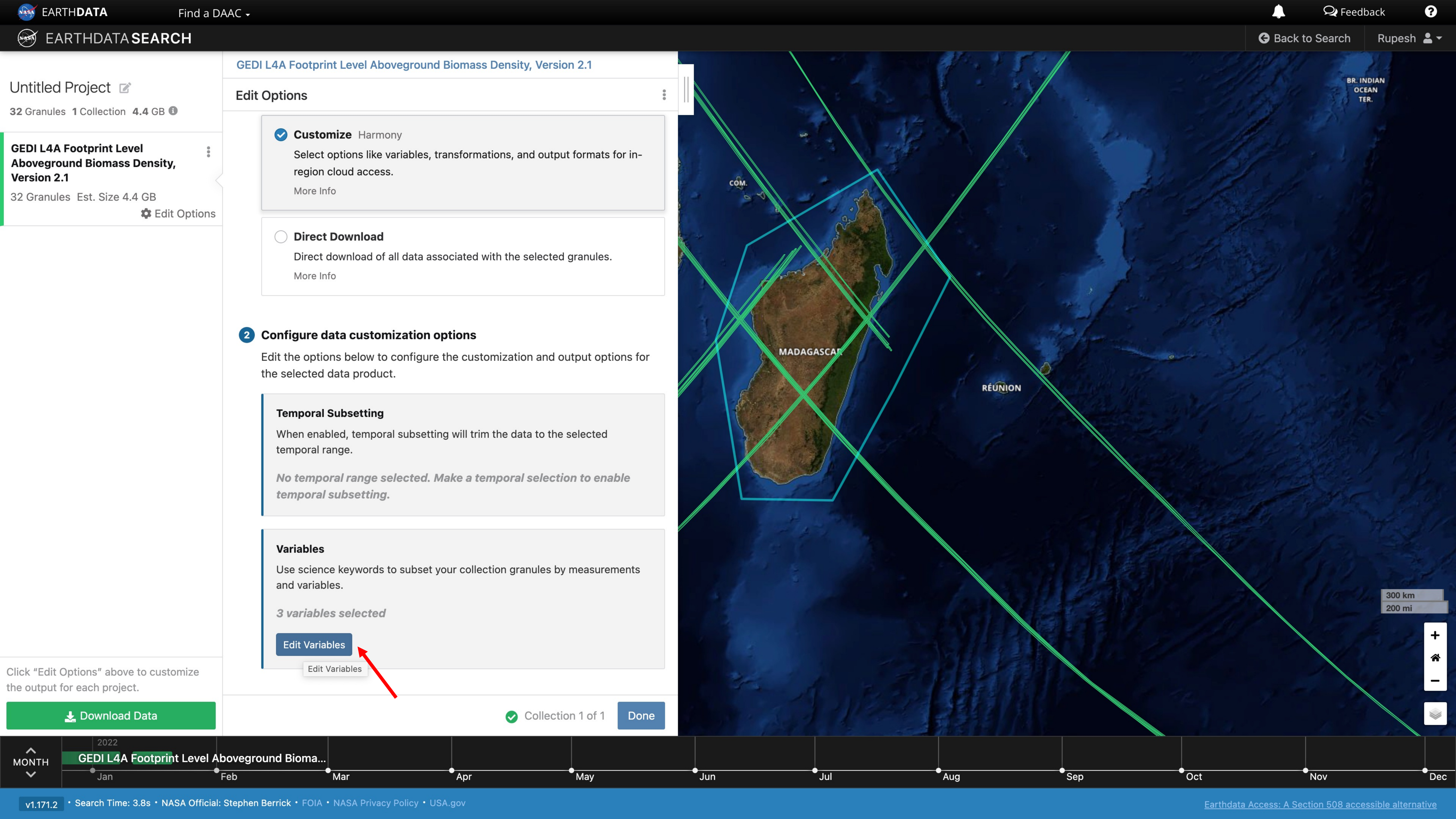
EARTHDATA
Find a DAAC
Feedback
EARTHDATA SEARCH
Back to Search
Rupesh
Untitled Project
32 Granules 1 Collection 4.4 GB
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
32 Granules Est. Size 4.4 GB
Edit Options
Click "Edit Options" above to customize the output for each project.
Download Data
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
Edit Options
Customize Harmony
Select options like variables, transformations, and output formats for in-region cloud access.
More Info
Direct Download
Direct download of all data associated with the selected granules.
More Info
2 Configure data customization options
Edit the options below to configure the customization and output options for the selected data product.
Temporal Subsetting
When enabled, temporal subsetting will trim the data to the selected temporal range.
No temporal range selected. Make a temporal selection to enable temporal subsetting.
Variables
Use science keywords to subset your collection granules by measurements and variables.
3 variables selected
Edit Variables
Edit Variables
Collection 1 of 1
Done
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GEDI L4A Footprint Level Aboveground Bioma...
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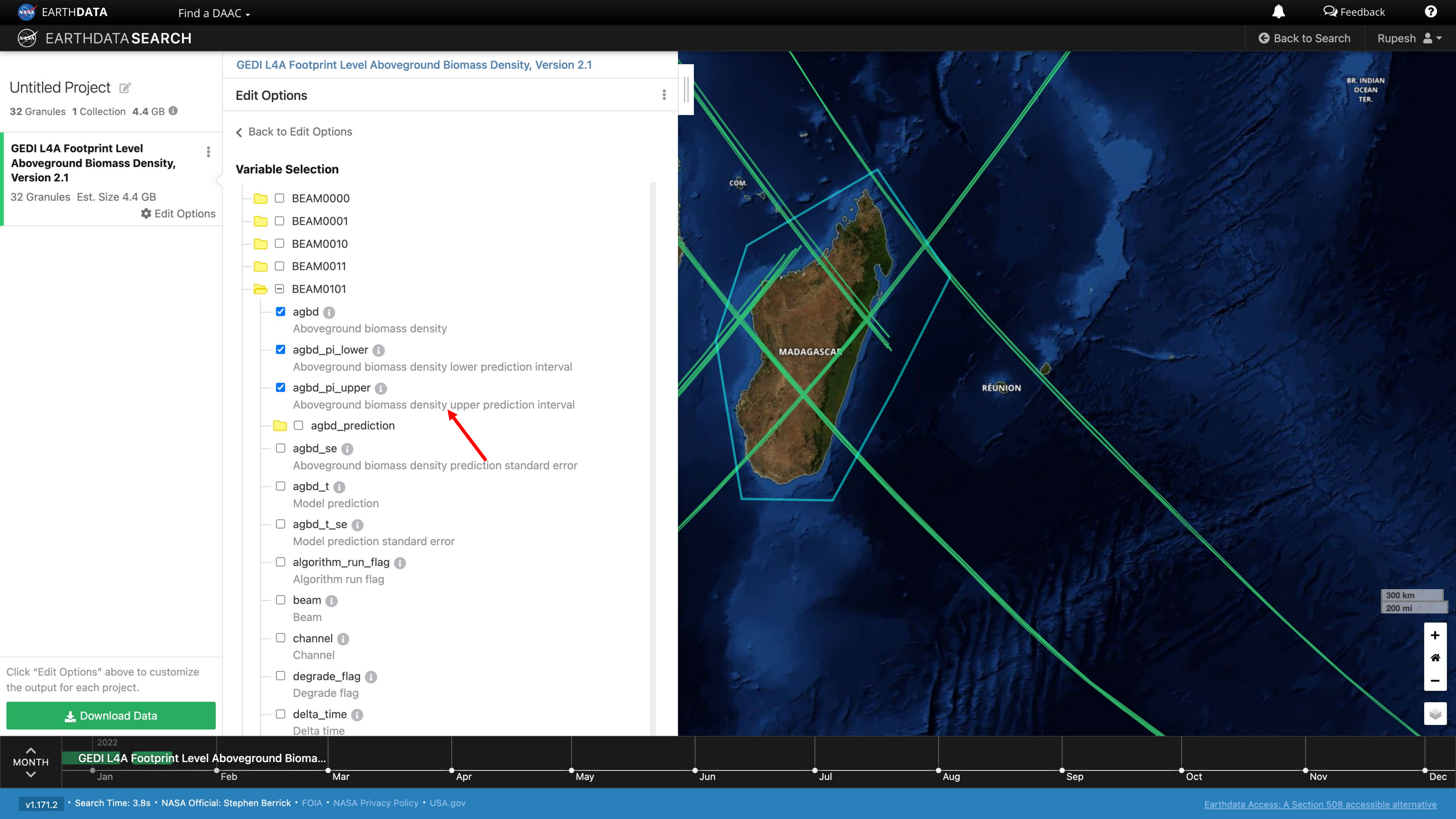
v1.171.2
Search Time: 3.8s • NASA Official: Stephen Berrick • FOIA • NASA Privacy Policy • USA.gov
Earthdata Access: A Section 508 accessible alternative


EARTHDATA
Find a DAAC
Feedback
EARTHDATA SEARCH
Back to Search
Rupesh
Untitled Project
32 Granules 1 Collection 4.4 GB
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
32 Granules Est. Size 4.4 GB
Edit Options
Click "Edit Options" above to customize the output for each project.
Download Data
GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1
Edit Options
Back to Edit Options
Variable Selection
BEAM0000
BEAM0001
BEAM0010
BEAM0011
BEAM0101
agbd
Aboveground biomass density
agbd_pi_lower
Aboveground biomass density lower prediction interval
agbd_pi_upper
Aboveground biomass density upper prediction interval
agbd_prediction
agbd_se
Aboveground biomass density prediction standard error
agbd_t
Model prediction
agbd_t_se
Model prediction standard error
algorithm_run_flag
Algorithm run flag
beam
Beam
channel
Channel
degrade_flag
Degrade flag
delta_time
Delta time
BR. INDIAN OCEAN TER.
COM.
MADAGASCAR
RÉUNION
300 km
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GEDI L4A Footprint Level Aboveground Bioma...
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GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1

Status	Access Method	Granules
In progress (0%) 0/1 orders complete	Harmony	32 Granules

Your orders are currently processing. Once processing is finished, links will be displayed below and sent to the email you've provided.

Download Files | STAC Links | Order Status

The download files will become available once the order has finished processing.

Additional Resources and Documentation

- https://doi.org/10.3334/ORNLDAAC/2056
- https://gedi.umd.edu

You might also be interested in

Download Status

This page will automatically update as your orders are processed. The Download Status page can be accessed later by visiting https://search.earthdata.nasa.gov/downloads/5438660340 or the Download Status and History page.

GEDI L4A Footprint Level Aboveground Biomass Density, Version 2.1

Status	Access Method	Granules
Complete (100%) 1/1 orders complete	Harmony	32 Granules

Your orders are done processing and are available for download.

Service has responded with message:

- The job has completed successfully

Download Files | STAC Links | Order Status

Retrieved 96 files for 32 granules

Copy | Save | Expand

https://harmony.earthdata.nasa.gov/service-results/harmony-prod-staging/public/sds/trajectory-subsetter/b2104532-052c-45f6-a955-9
https://data.ornldaac.earthdata.nasa.gov/public/gedi/GEDI_L4A_AGB_Density_V2_1/data/GEDI04_A_2020032073006_O06448_01_T046
https://opendap.earthdata.nasa.gov/collections/C2237824918-ORNL_CLOUD/granules/GEDI_L4A_AGB_Density_V2_1.GEDI04_A_20200З
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https://data.ornldaac.earthdata.nasa.gov/public/gedi/GEDI_L4A_AGB_Density_V2_1/data/GEDI04_A_2020052120529_O06761_04_T028
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https://harmony.earthdata.nasa.gov/service-results/harmony-prod-staging/public/sds/trajectory-subsetter/b2104532-052c-45f6-a955-9
https://data.ornldaac.earthdata.nasa.gov/public/gedi/GEDI_L4A_AGB_Density_V2_1/data/GEDI04_A_2020051234222_O06753_01_T020
https://opendap.earthdata.nasa.gov/collections/C2237824918-ORNL_CLOUD/granules/GEDI_L4A_AGB_Density_V2_1.GEDI04_A_202005
https://harmony.earthdata.nasa.gov/service-results/harmony-prod-staging/public/sds/trajectory-subsetter/b2104532-052c-45f6-a955-9
https://data.ornldaac.earthdata.nasa.gov/public/gedi/GEDI_L4A_AGB_Density_V2_1/data/GEDI04_A_2020033064330_O06463_01_T038
https://opendap.earthdata.nasa.gov/collections/C2237824918-ORNL_CLOUD/granules/GEDI_L4A_AGB_Density_V2_1.GEDI04_A_20200З

Additional Resources and Documentation

- https://doi.org/10.3334/ORNLDAAC/2056

Questions?