Hobby Drones, Urban Forests

A Geospatial Journey To Greener Cities

Kevin Lacaille | July 8, 2024

A little bit about me

Astrophysics
Software engineering
Mountain biking, skiing, cooking

Today we will

Learn geospatial concepts

Python for image analysis

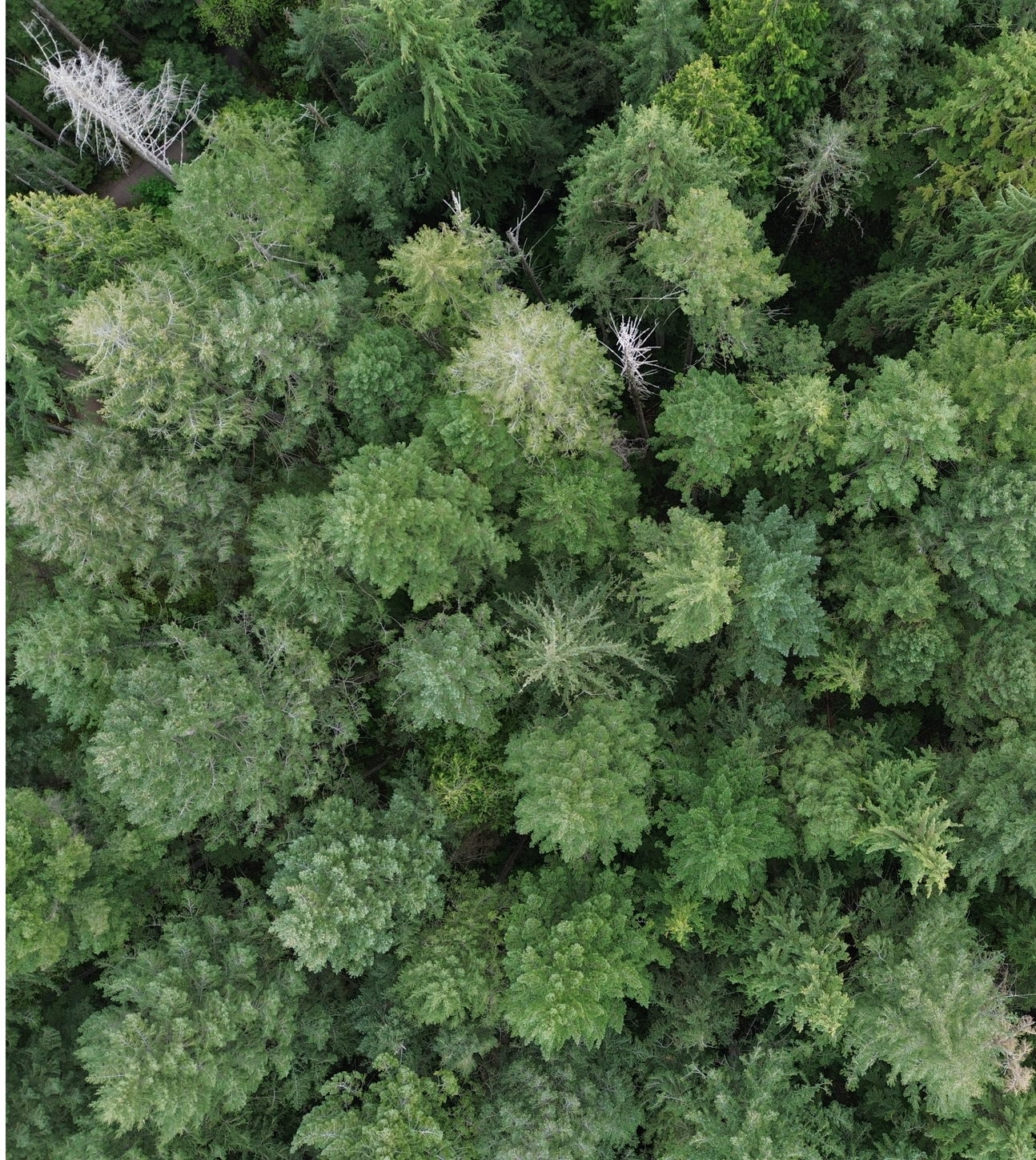
Apply to real-world example

The Why

Drone Imagery for Climate

How do we use it effectively?

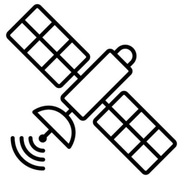
- Climate change urgency
- High-res imagery
- Accessible and cost effective
- Real time monitoring
- Urban planning and sustainability



Drone Imagery

Geospatial Data Source

Satellite



- Low res (0.3-10m)
- Long wait (~1 month)
- Limited by weather & atmosphere
- Large coverage
- Limited by satellite’s orbit
- Requires professionals
- Expensive

Aerial

- Medium res (0.1-1m)
- Long wait (~1 week)
- Limited by weather
- Large coverage
- Can fly most places
- Requires professionals
- Expensive

Drone

- High res (0.03m)
- Almost no wait (~4hr)
- Limited by weather & battery life
- Small coverage
- Can fly most places
- Easy to operate
- Inexpensive

Micro Drones

A bit about hobby drones

DJI micro drones

Portable, cost effective, high-quality imaging

- Weight <250g
- 3cm (1 inch) resolution
- Flight time >30 min
- No FAA registration required
- <$500

Core Geospatial Concepts

Spatial Data is Special

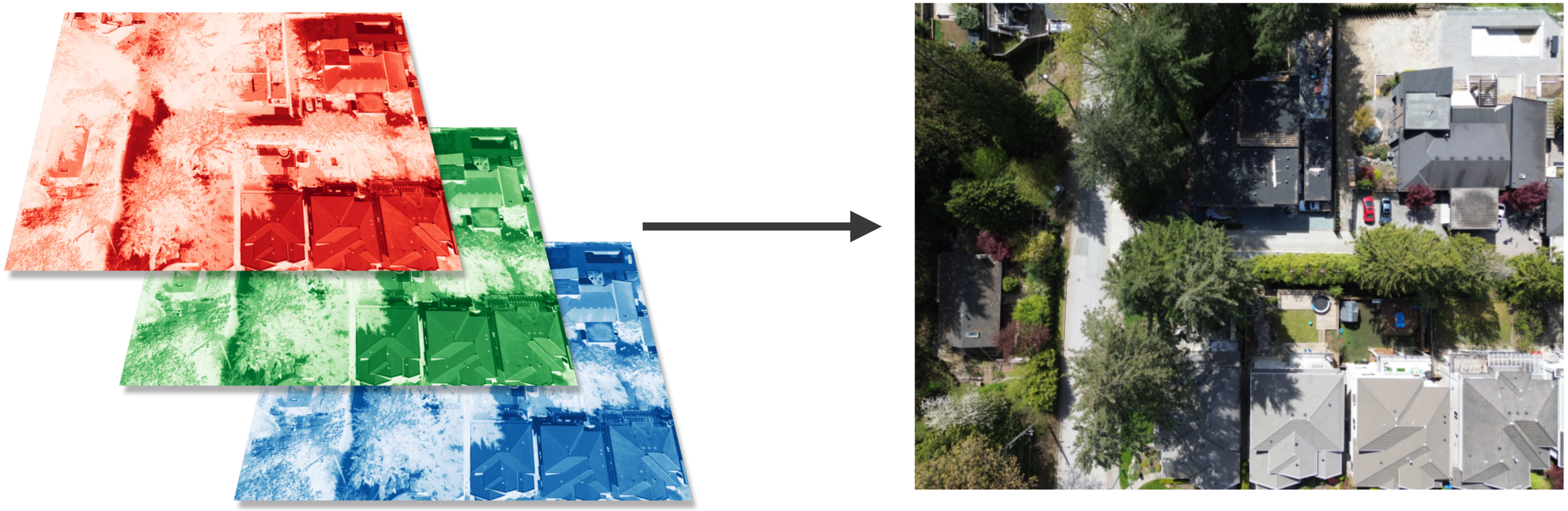
Unique qualities of drone imagery require special consideration

Geospatial Raster Imagery

- Is spatially referenced
- Has spatially-relevant metadata
- Is multispectral

Multispectral Imagery

An image contains 3 spectral bands



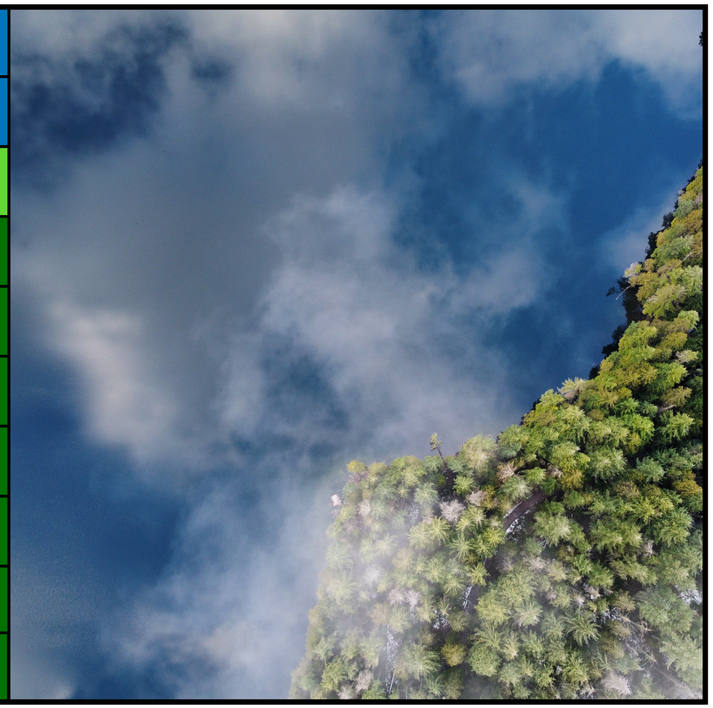
Drone imagery requires special consideration

Using non-geospatial Python imagery libraries can have unexpected results

Rasters, Pixels, and 2D Arrays

Representing Remote-Sensing Data

1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	2
1	1	1	1	1	1	1	1	1	4
1	1	1	1	1	1	1	1	4	4
1	1	1	1	1	1	1	3	4	4
1	1	1	1	1	3	3	4	4	4
1	1	1	1	2	4	4	4	4	4
1	1	1	1	3	4	4	4	4	4
1	1	1	1	3	4	4	4	4	4

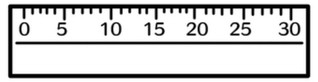


Pixels in a raster dataset are arranged in a grid

Pixels representing equivalent data have the same value.

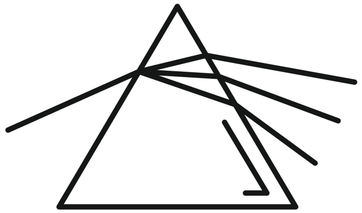
Defining Resolution in Drone Imagery

Spatial resolution: Pixel size on the ground

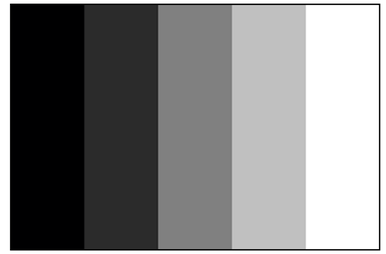


Temporal resolution: Frequency between image captures

Spectral resolution: Number of spectral bands measured



Radiometric resolution: Number of shades of a colour



Geospatial Tools & Libraries

Python Libraries

Geospatial, math, data viz, & computer vision

`Rasterio`

- Read and write geospatial raster data represented as 3D arrays

`PyExifTool`

- Extract meta-information from images

`Numpy`

- Read, write, and manipulate multi-dimensional arrays and matrices

`Matplotlib`

- Plotting library

`OpenCV`

- Computer vision library used for image processing, object detection, segmentation, etc.

Workshop Setup

Good news! Open source tools exist to make this setup easy.

You can access an instance of this workshop's Jupyter Notebook collection

github.com/kevinlacaille/presentations/tree/main/scipy2024

Notebook Time!

github.com/kevinlacaille/presentations/tree/main/scipy2024

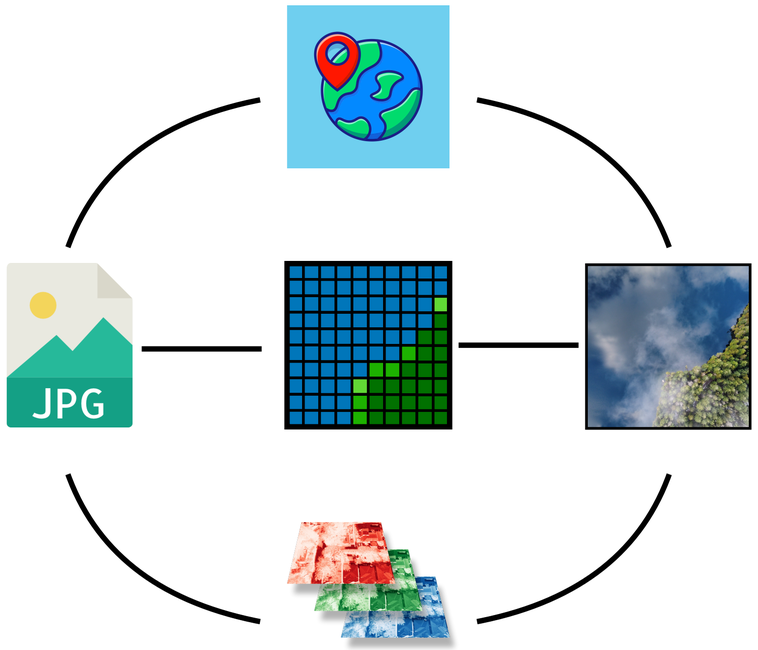
Extract Bands & Compose Scene

Use `rasterio` to extracting metadata from an image, including

- Coordinate reference system
- Resolution
- Bands

Decomposing a 3-band image

Use `numpy` to combine bands and create visual image



Reference: `1_rasters.ipynb`

Extract and Utilize EXIF Data

Extracting metadata from an image using `exiftool`

- Estimate size of objects using context of the scene

Reference: `2_exif.ipynb`

Compute VARI

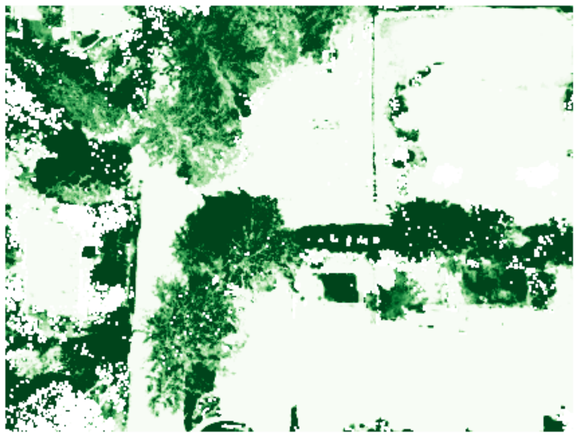
Visible **A**tmospherically **R**esistant **I**ndex (**VARI**)

- Emphasizes vegetation in the visible portion of the spectrum
- Mitigates illumination differences
- Hobby drone sensors are un calibrated - need to do it ourselves

$$\text{VARI} = \frac{\text{green} - \text{red}}{\text{green} + \text{red} - \text{blue}}$$

RGB

VARI

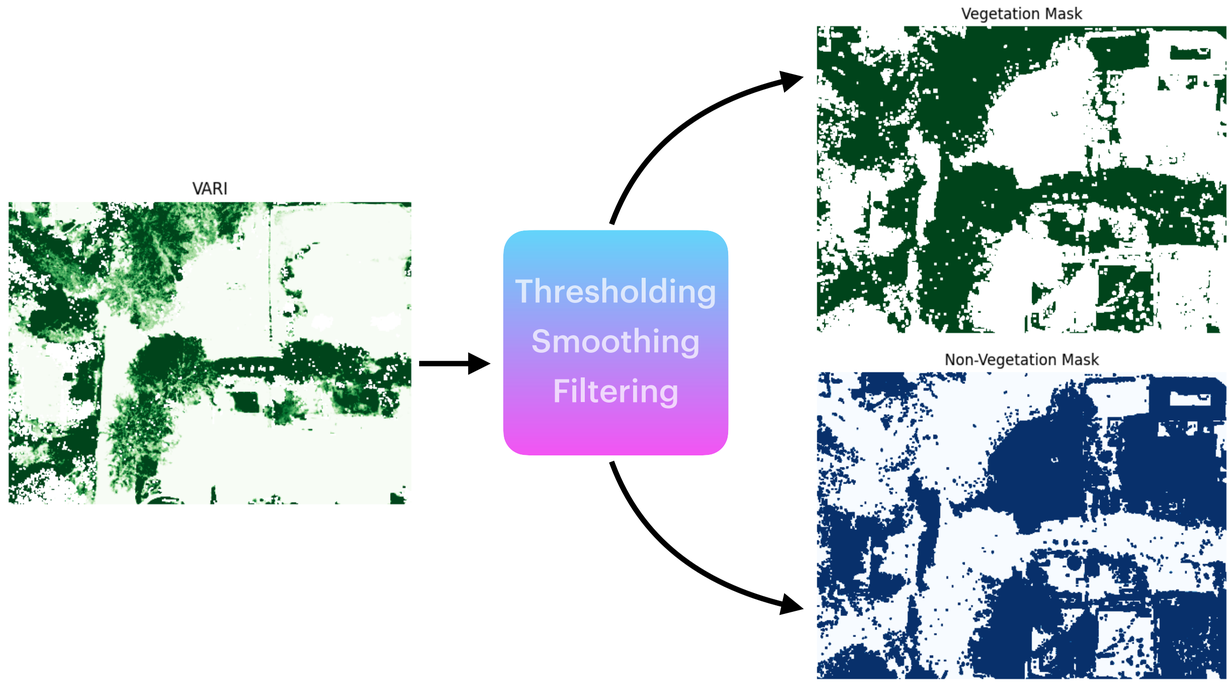


Reference: `3_vari.ipynb`

Masks & filters

Apply a series of image processing techniques to VARI image

- Image thresholding
- Gaussian blurring
- Morphological filtering (opening and closing filters)



Reference: `4_masks_and_filters.ipynb`

Remote sensing based segmentation

Don’t have tons of annotated data?

Don’t have time or resources to train an ML model?

Don’t know how ML works?

Use science and context of a scene to our advantage!

- VARI, drone altitude, true size of objects, time of day, camera properties, etc.

vegetation segmentation

non-veg segmentation

Reference: `5_segmentation.ipynb`

Hands-on Exersize

A geospatial & computer vision analysis of urban trees?

1. Import and process drone imagery
2. Create an image processing pipeline
3. Develop a segmentation algorithm to find all trees in a scene
4. Estimate carbon capture for city
5. Drawbacks

Reference: `6_image_processing.ipynb`

What Can I do?

Become a pilot and contribute!

Spexi


Get in touch
kevinlacaille@gmail.com