TREE CANOPY ANALYSIS

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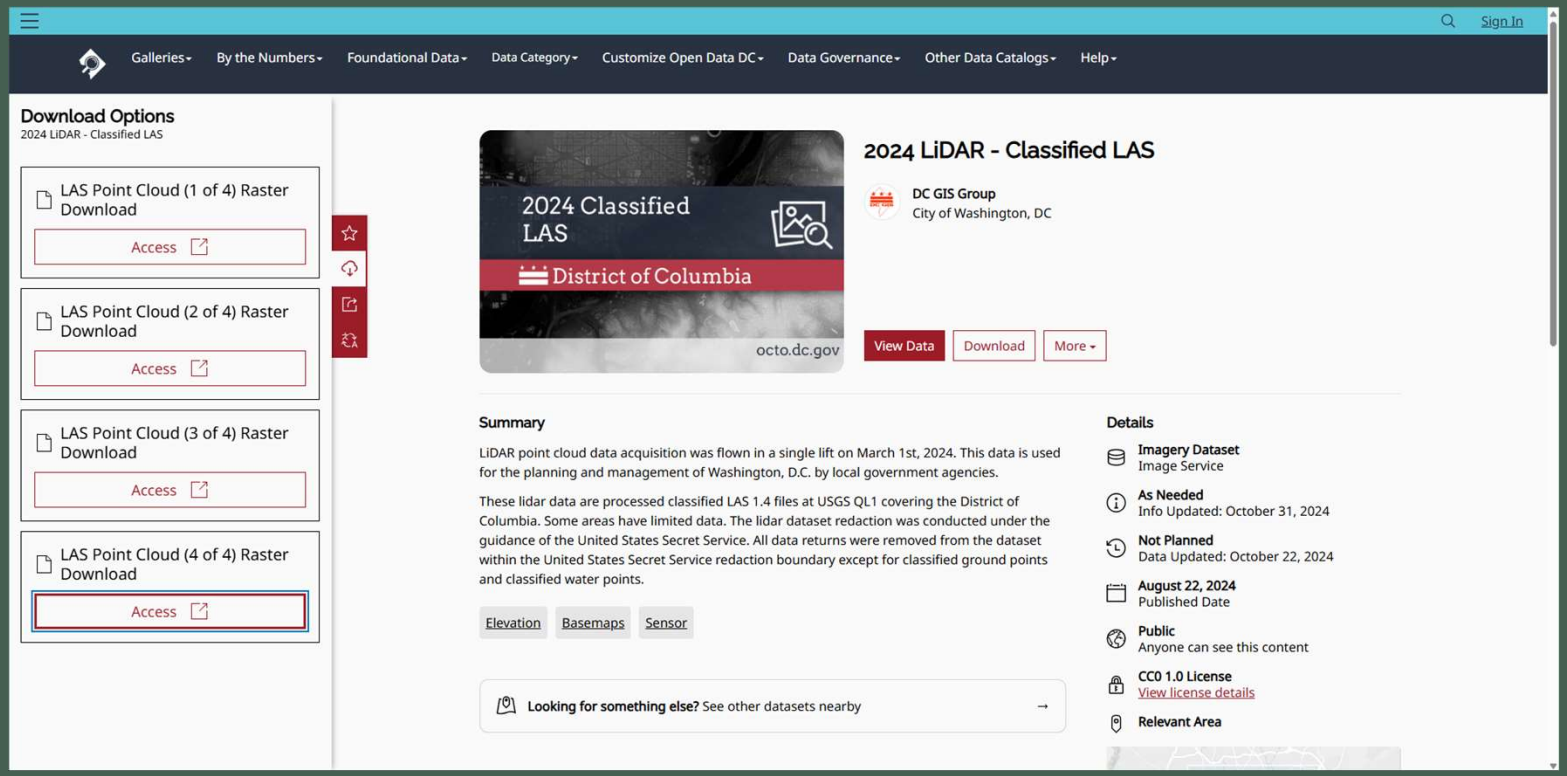
ABOUT THE METHODOLOGY

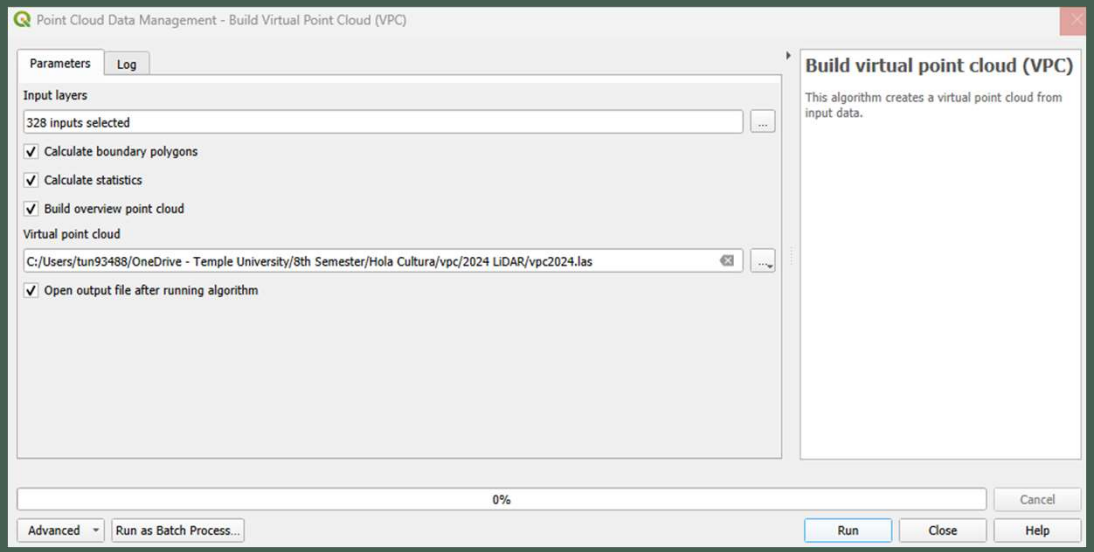
- This methodology is a pixel-based tree top and tree canopy analysis conducted through QGIS 3.40
- All data and software used in this methodology is open-source and free to download

1: DOWNLOAD CLASSIFIED LAS

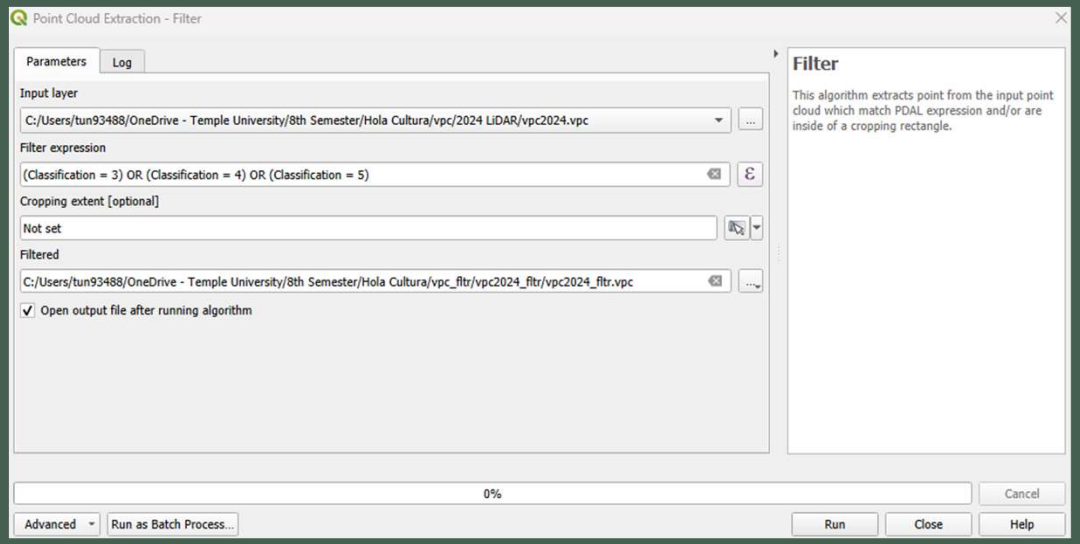


2: CREATE VIRTUAL POINT CLOUD

- In Processing Toolbox, go to **Point Cloud Conversion** -> **Build virtual point cloud (VPC)**
- Insert LAS files and turn on the following options:

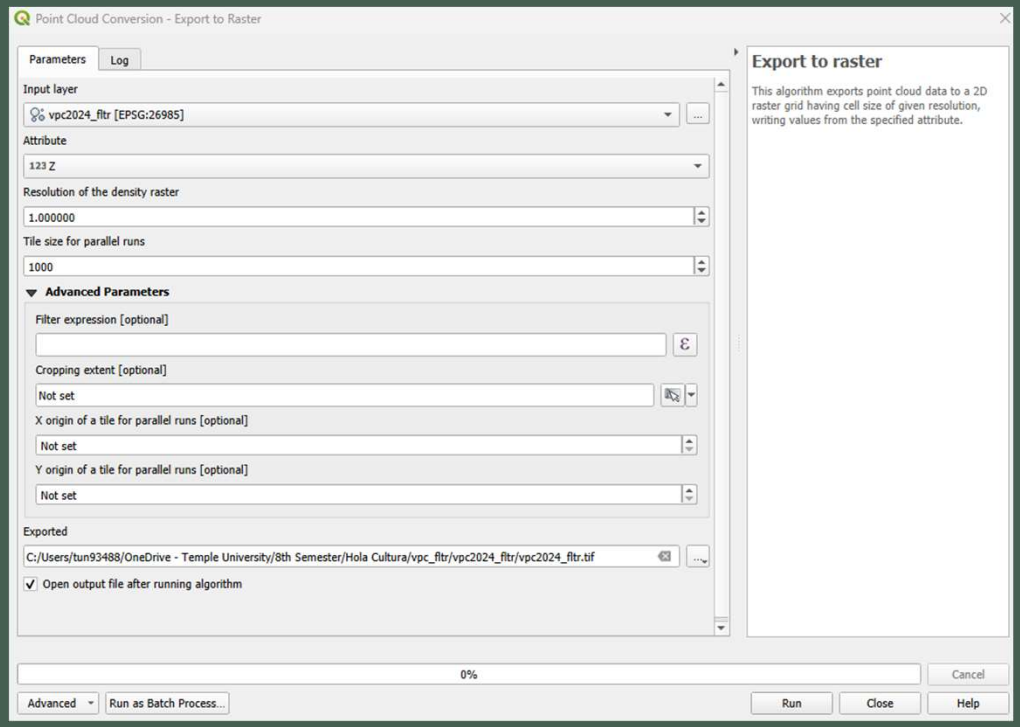


3: FILTER POINT CLOUD



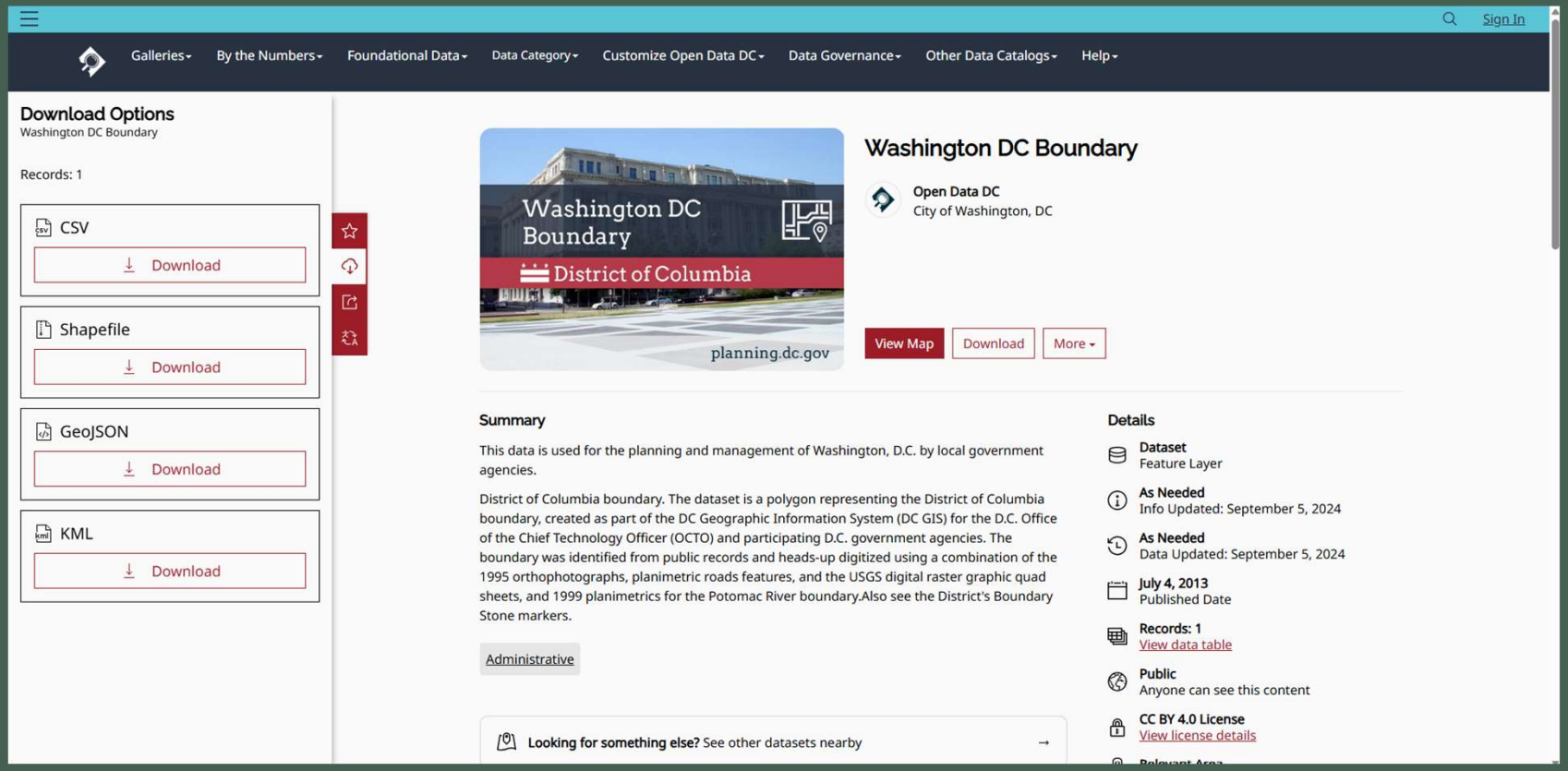
- In Processing Toolbox, go to **Point Cloud Extraction -> Filter**
- Select virtual point cloud layer as input
- Create filter expression to filter point cloud by vegetation classification
  - (Classification = 3) OR (Classification = 4) OR (Classification = 5)
- Set output layer as .vpc

4: EXPORT TO RASTER



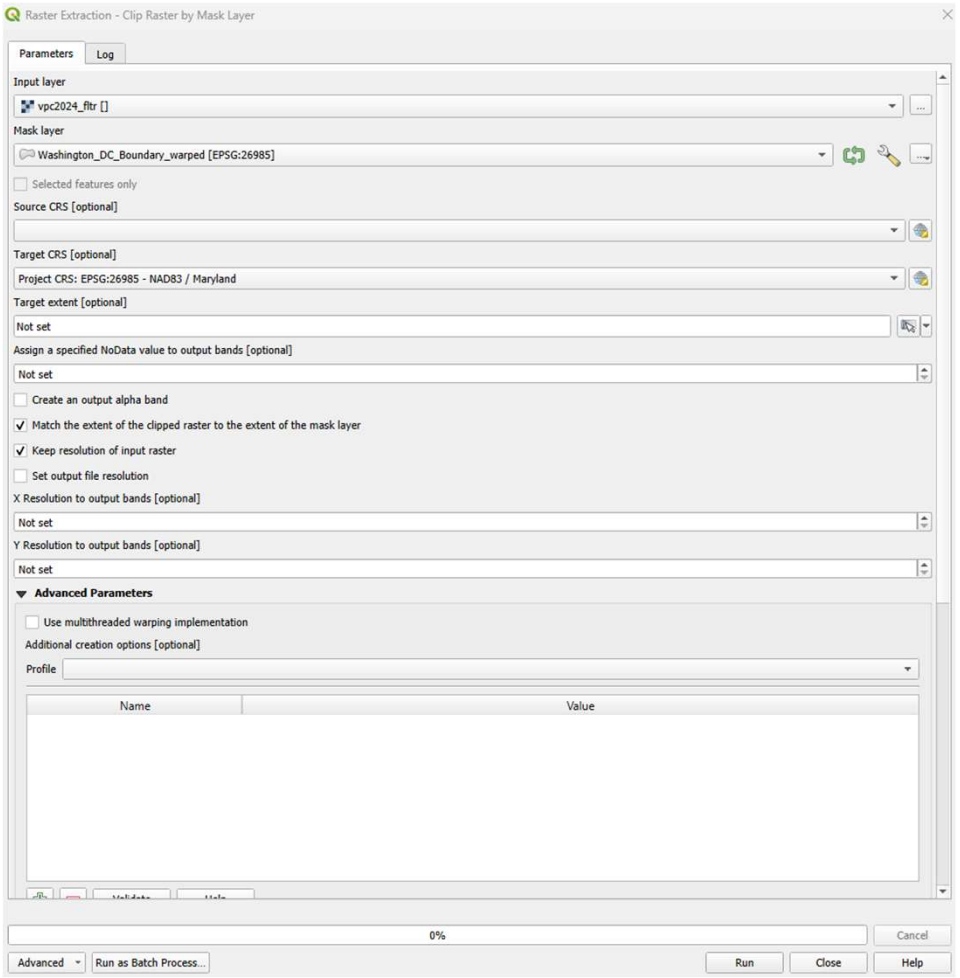
- In Processing Toolbox, go to **Point Cloud Conversion** -> **Export to raster**
- Select filtered point cloud as input
- Result of this process is a **DSM** raster of just vegetation

5: DOWNLOAD WASHINGTON, DC BOUNDARY SHP

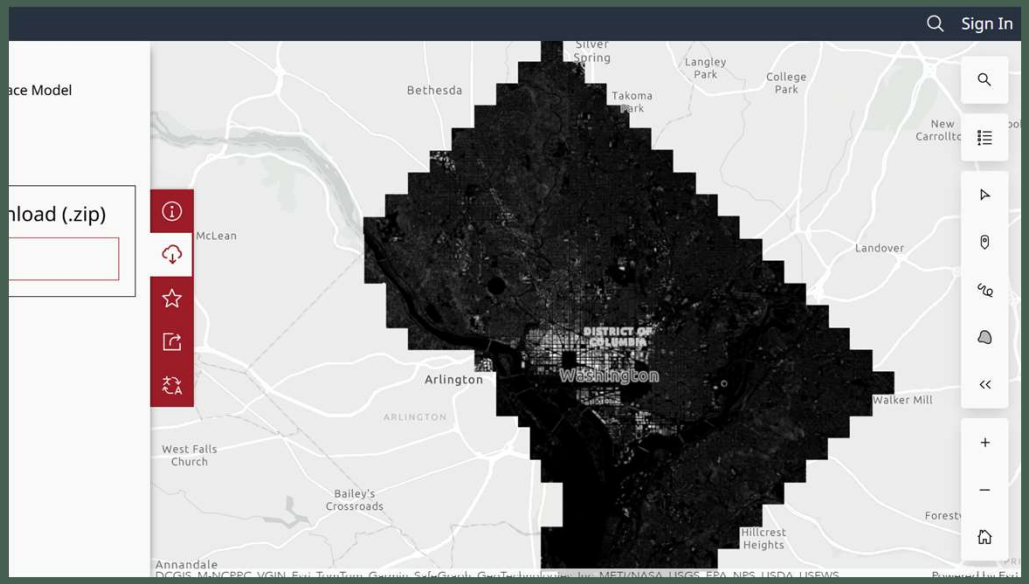


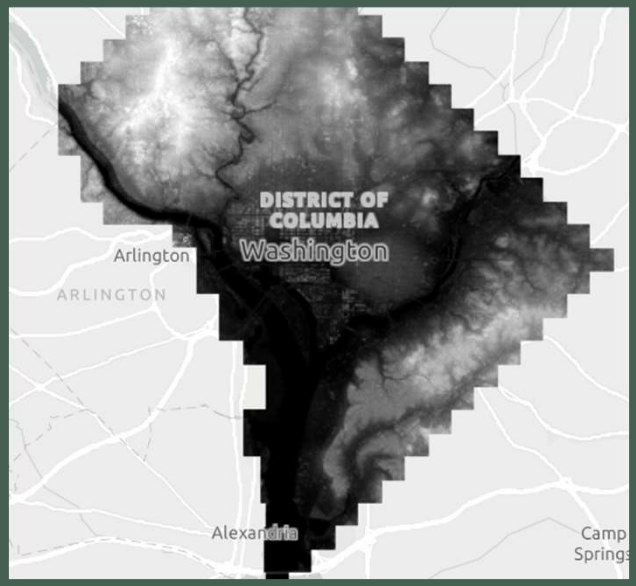
6: CLIP RASTER TO MASK LAYER

- On the top bar, go to **Raster -> Extraction -> Clip Raster by Mask Layer**
- Select filtered raster as input and Washington, DC boundary as mask
- Set Target CRS to one appropriate for DC, such as EPSG: 26985
- Check Keep resolution of input raster

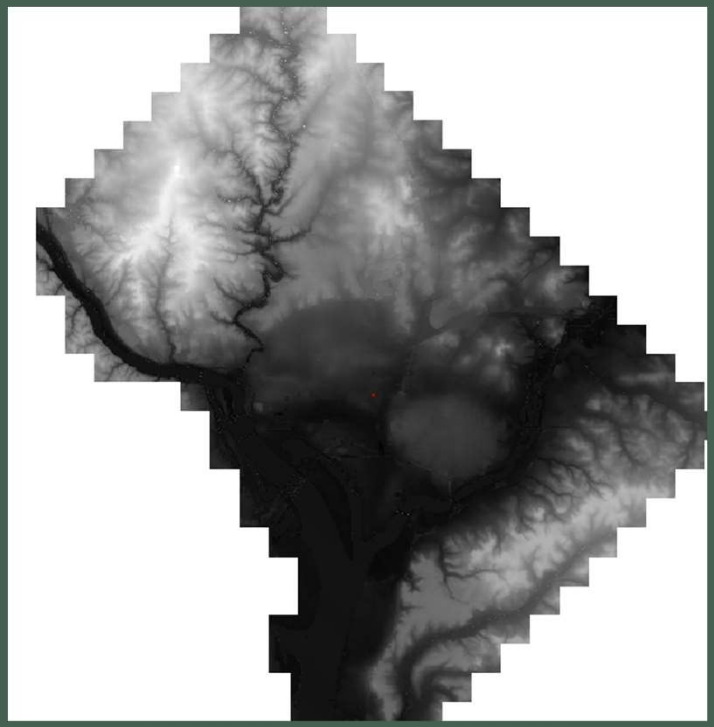


7: DOWNLOAD DSM AND NORMALIZED DSM (NDSM) FROM OPENDATA DC





8: CALCULATE DTM



- In Raster Calculator enter the following formula and save the output
- **DSM - nDSM**

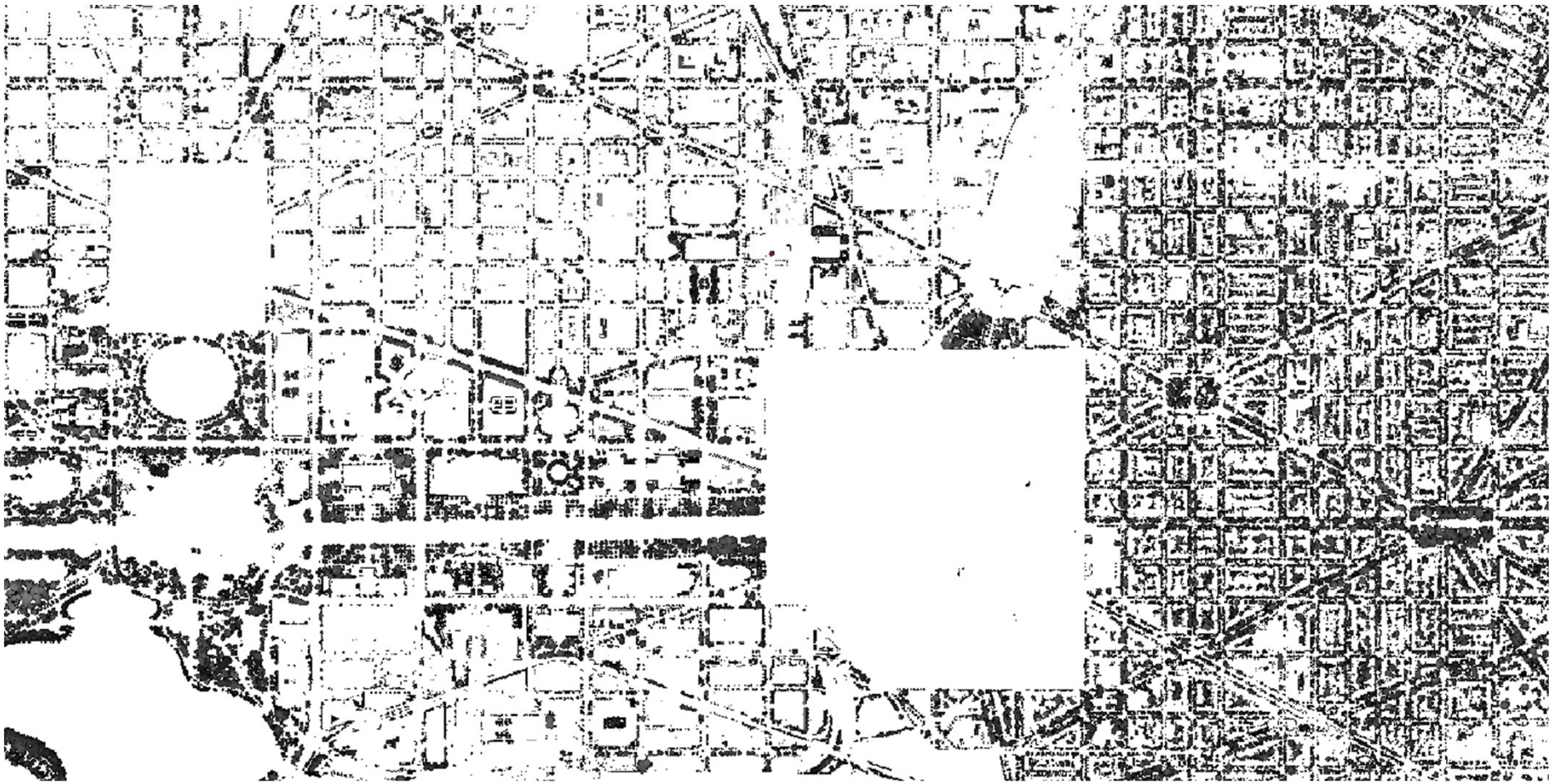
9: CALCULATE CHM

In Raster Calculator, calculate **Raw CHM** as **"full_dsm@1" - "dtm@1"**

Create Vegetation mask through the formula **"vegetation_dsm@1" > 0**

Calculate vegetation CHM = **"CHM_raw@1" * ("veg_mask@1" > 0)**

The apply threshold **"CHM_veg@1" * ("CHM_veg@1" >= 3)**



10: DOWNLOAD WASHINGTON, DC BUILDING FOOTPRINTS

https://opendata.dc.gov/datasets/DCGIS::building-footprints/about

Closest matches were 2024 and 2021

11: DETERMINE LOCAL MAXIMA:

- Part 1: Create Smooth CHM
  - In Processing Toolbox, go to **SAGA Next Gen** -> **Gaussian Filter**
  - Set **Kernel Radius** to 3
- Part 2: Create Local Maxima Points
  - In Processing Toolbox, go to **SAGA Next Gen** -> **Local Minima/Maxima**
  - Input **smooth CHM**
  - Save maxima output
- Part 3: Disjoint Local Maxima from Buildings
  - In Processing Toolbox, go to **Vector Selection -> Extract by Location**
  - Input Local Maxima and select to disjoint from buildings layer
    - Create spatial index for input first in settings -> source

12: FIX INVALID GEOMETRIES (IF APPLICABLE)

- When performing the disjoint, you might get an error that some of the buildings have invalid geometries
- In Vector Geometry, find Check Vector
- Input buildings raster
- Running this will produce separate layers for valid and invalid geometries and error points. The points represent exact spots of invalidity
- Manually fix invalid geometries by removing unnecessary points from polygons

13: CALCULATE TREE CANOPY VIA PYTHON

- In your environment, install rasterio by running the following:
  - conda install -c conda-forge rasterio
- Run the following code in your script editor:

```
import rasterio
import numpy as np
import os

os.chdir('C:/Users/tun93488/OneDrive - Temple University/8th
Semester/Hola Cultura/CHM')

# List of CHM files
chm_files = [
   "C:/Users/tun93488/OneDrive - Temple University/8th
Semester/Hola Cultura/CHM/CHM2020/CHM2020_3m.tif",
   "C:/Users/tun93488/OneDrive - Temple University/8th
Semester/Hola Cultura/CHM/CHM2024/CHM2024_3m.tif"]

# Canopy height threshold (meters)
threshold = 3.0

for chm_path in chm_files:
   with rasterio.open(chm_path) as src:
      chm = src.read(1)
      profile = src.profile
      pixel_area = abs(src.transform[0] * src.transform[4])  # pixel
size in m²

   # Create binary canopy mask
   canopy_mask = chm > threshold

   # Count canopy pixels
   canopy_pixels = np.sum(canopy_mask)

   # Total canopy area
   canopy_area_m2 = canopy_pixels * pixel_area

   print(f"{chm_path}:")
   print(f"  Total canopy area: {canopy_area_m2:.2f} m²")
```

RESULTS

	2020	2024	Difference	% Diff.
Individual Tree Count	926,880	1,345,997	+419,117	+ 31.1%
Tree Canopy Area	76,002,424 m^2	61,909,645 m^2	-14,092,779	-18.5%
Comparison to DC's Area	42.9%	35.0%		