

Open GIS tools & mapping your data



Introduction

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Note:

Part 1 of a 2-part series (May 1st, 1 pm)

Contact us if you want to discuss GIS data, policy, software, analysis, or visualization of data

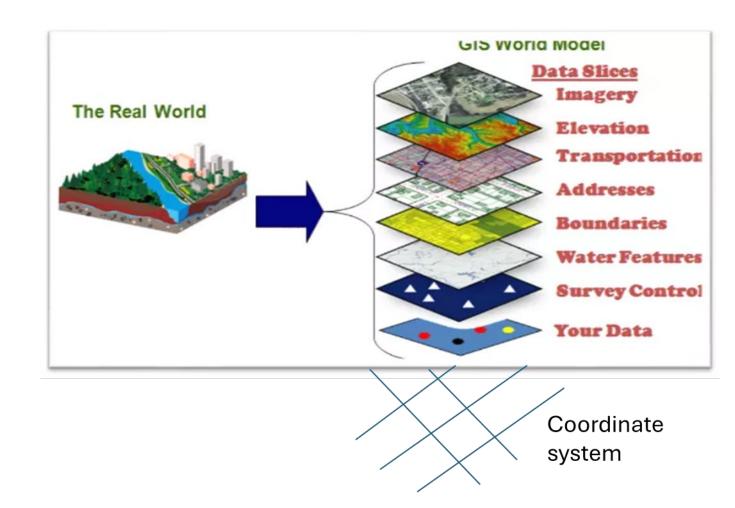
GIS Software Reference Sheet available

What tutorial topics do you want?



Basic geospatial model

- Data stacks in a geographic coordinate system
- Often represents physical entities or models the RW
- Flexible data types





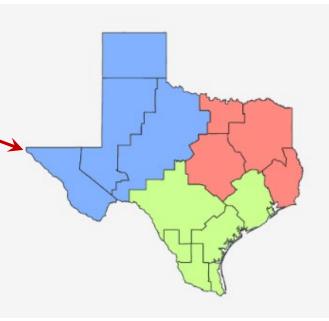
GIS software is a spatially-enabled database

- Each record corresponds to a location or point
- You can query the database
 - New information
 - Large scale
- No analysis or scale limits
- Aggregation to any geography
- Visualization
- Model's reality

Sales Territory	Dealer	Total Sales
Big Bend E	Tom	2315486
Big Bend N	Tom	1005364
Hill & Lakes	Tom	1149852
Hill & Plains	Tom	1356589
South Plains E	Dick	98543
South Plains S	Dick	149056
Gulf Coast S	Dick	300488

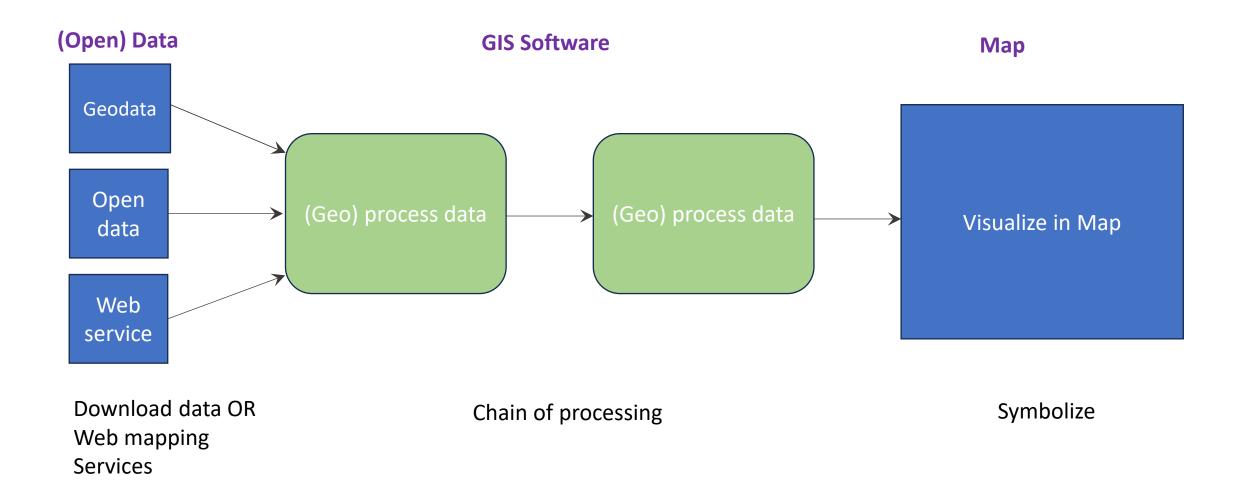
DB/Table

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Typical workflow





GIS data types

Symbiosis between data types and data tools

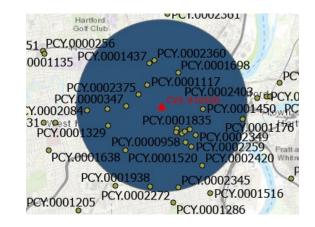


What are the basic GIS data types?

GIS data

- Location data with geographic coordinates
- Vector:
 - Point, line, polygon
 - Lidar point cloud
 - Shape file, fc, geoJSON
- Not just shape files!
- Raster
 - Aerial and satellite images
 - Elevation surface
 - Geotiff, .tif, many others
- Non-spatial to spatial (geocoding and chloropleths)
- Delivered via web services or download







What are the basic GIS data types?

Vector

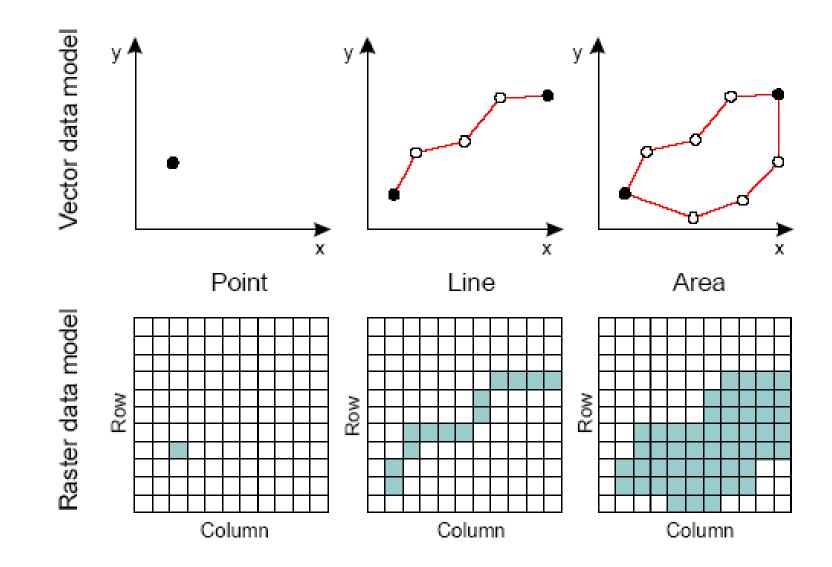
- Each point has a specific position
- Primitives are point, line, and polygon
- Location data with geographic coordinates
- Examples:
 - Point, line, polygon
 - Lidar point cloud
 - Shape file, fc, geoJSON
- Often created via digitizing, feature extraction, or geocoding
- Delivered via web services or download

Raster

- Matrix positioned in space
- Primitives are called pixels, cells, or a grid
 - Essentially a surface
- Examples
 - Aerial and satellite images
 - Elevation surface
 - Geotiff, .tif, many others
- Typically derived from imagery or DEM
- Often created via interpolation or conversion
- Delivered via web services or download

Critical: Different set of tools utilized for each data type

Vector data compared to raster data

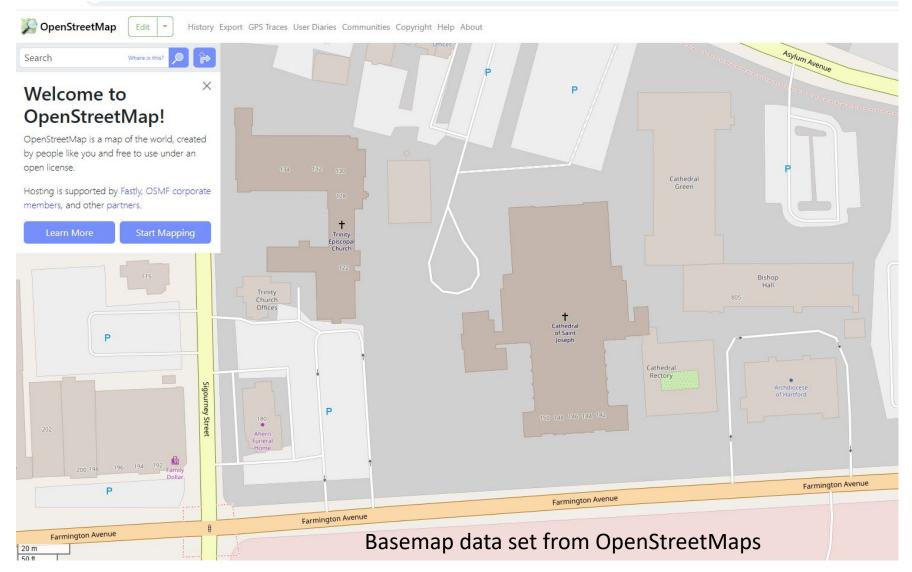


Found at: https://worldbank.github.io/OpenNightLights/tutorials/mod5_3_vector_and_raster_data.html 9



Aerial imagery from the 2023 capture

OpenStreetMap (Vector)



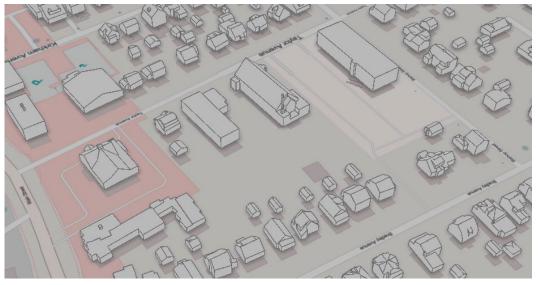
Data & Policy Analytics

2023 imagery



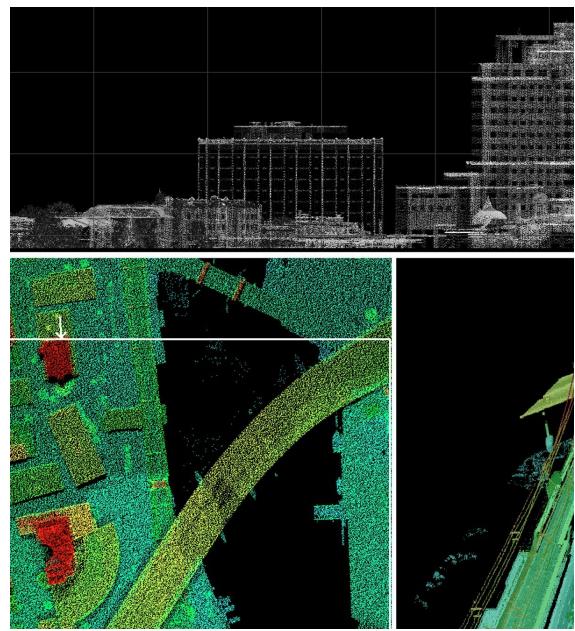
2 bldg. footprints from 2023 capture





3d bldg. footprints from 2023 capture

Lidar point cloud of Bridgeport



Lidar Data





Vector or raster? Image intensity data set



Acquisition of data



Acquiring data: Download vs web services

- Download keeps data in a single structure (locally)
- Web services pull data from server using specific protocol
 - Typ. authoritative, light, up-to-date
- Variety of formats.
 - Tiles and vector services
- User finds a web mapping URLs as well as tabular URLs
- Web Mapping Services: An Introduction
- QGIS and WMS

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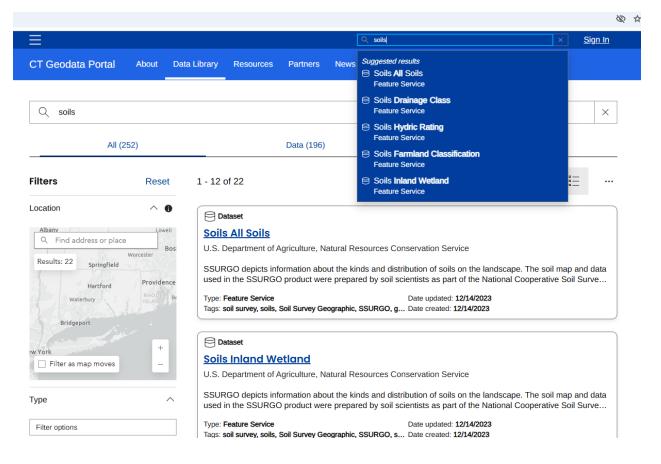
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• <u>CT Geodata Portal</u>

 Data, services, features, mostly spatial





Download or web services or both



CT Aerial Imagery and Lidar Elevation

- <u>CT Eco</u>
 <u>Aerial</u>,
 <u>Imagery and</u>
 <u>Lidar</u>
 <u>Download</u>
- Data download site for imagery and Lidar

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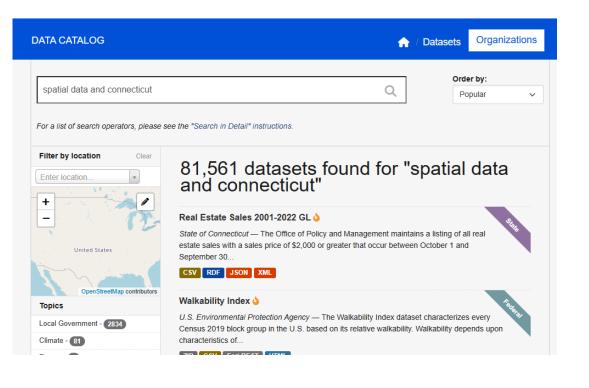
- <u>CT Open Data</u>
- Mostly tabular
- Data with geographies or addresses can be converted to spatial data

List of geocoded businesses holdir Credentials recorded in Connecticu	g a "PHARMACY" license from Licenses and t's eLicensing system.	Last Updated March 28, 2025
	Export dataset	× rtment of Consumer ction
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March 28, 2025	CSV TeoJSON	ervices
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October 2, 2019	RDF	
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	Shapefile business,	, health

Download or web services or both



- <u>Data.gov</u>
- Geoplatform
- <u>Living Atlas of the</u> <u>World</u>
 - Web services
 - Numerous free services scaped or contributed from governments, academy, and nonprofits
- Federal agencies, states, regional planning agencies, towns



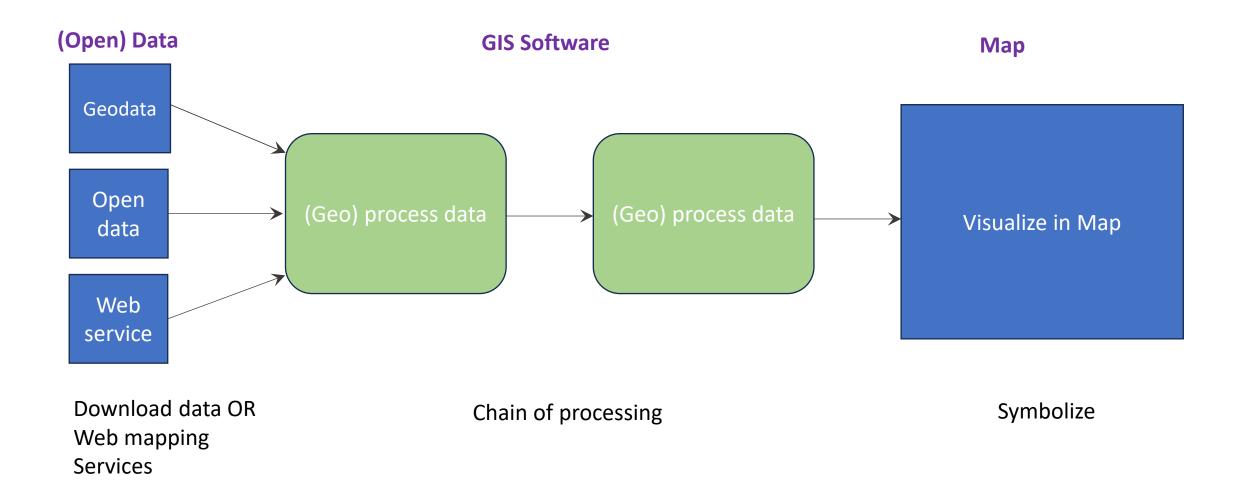




Software



Typical workflow





GIS software overview

- Works within a GIS community system
- Key tasks:
 - Maps and visualization, digital twins and simulation, analysis, and statistics, data management and automation, mapping services, analysis
- Commercial vs. open source
 - Ex. ESRI is biggest vendor, but can be expensive
- World of open GIS software allows free access and usage
- Rise of data science has hybridized GIS and data science





Types of GIS software

- Stand alone "reader" tools' (free)
 - QT Reader
 - FugroViewer
 - Pyramid Shader
 - ET Spatial Data Viewer
- Quickly check out tiles for viewing and manipulation
- Best for manipulation of one tile



FugroViewer is a robust, easy-to-use freeware designed to help users make the most of their geospatial data. We have developed it for use with various types of raster- and vector-based geospatial datasets, including data from photogrammetric, lidar, and IFSAR sources.

FugroViewer 3.5 is available for download. FugroViewer now reads files up to six times larger, with improved graphics handling to decrease the rendering time of data and increasing efficiency. FugroViewer supports the latest open file format for lidar data storage and delivery - American Society for Photogrammetry and Remote Sensing (ASPRS) latest LAS 1.4.

FugroViewer Download QT Reader Download



FugroViewer Demo: Lidar and Imagery

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Point Clouds P Meshes De Vectors Barkers

• CT Eco download tool

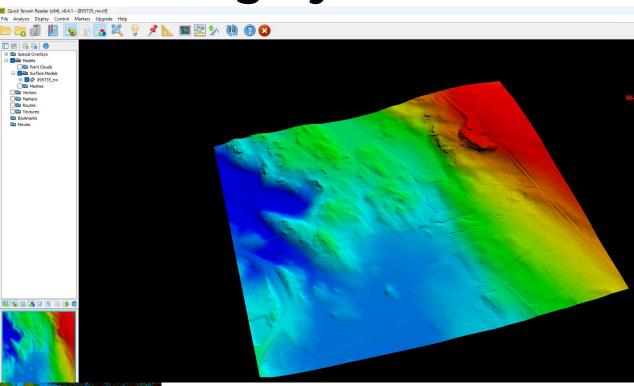
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• QT Reader or FugroViewer

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Quick Terrain Reader (x64), v8.4.1 - [735580_ne.laz] e Analysis Display Control Markers Upgrade Help



Quick Terrain Reader

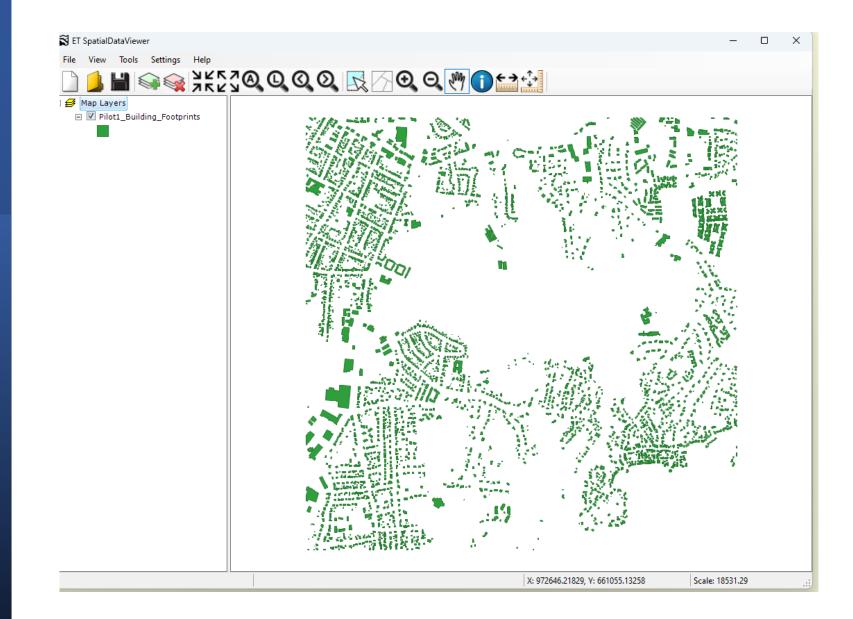
Free viewing software

The current version of Quick Terrain Reader is loading your DEMs and/or point clouds, please version below.

④ Quick Terrain Reader

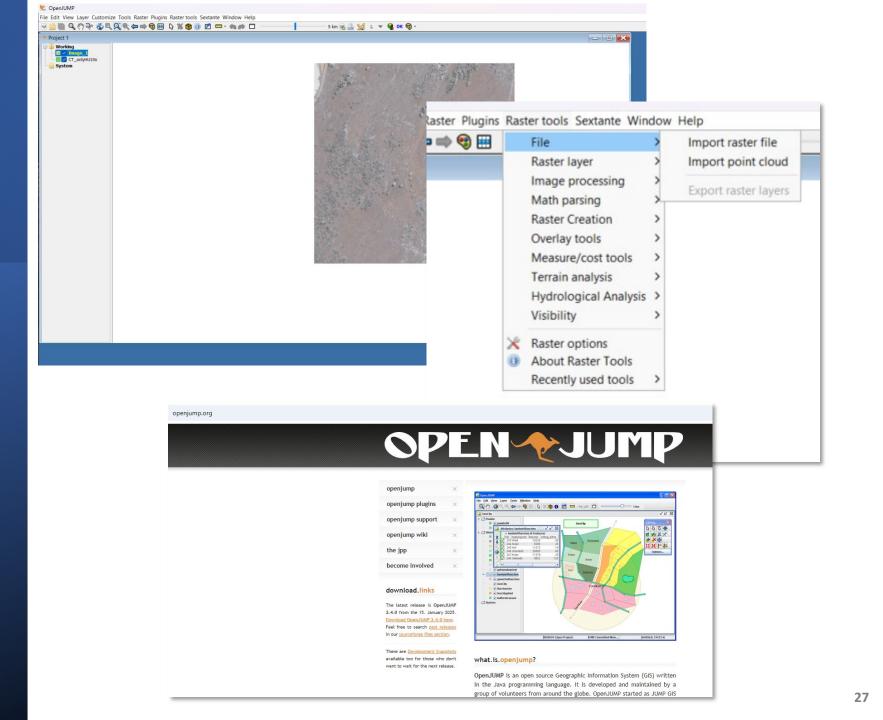
ET SpatialData <u>Viewer</u>

Simple Vector Reader



OpenJump GIS

Vector and Raster "Light" GIS





Desk stop software: QGIS

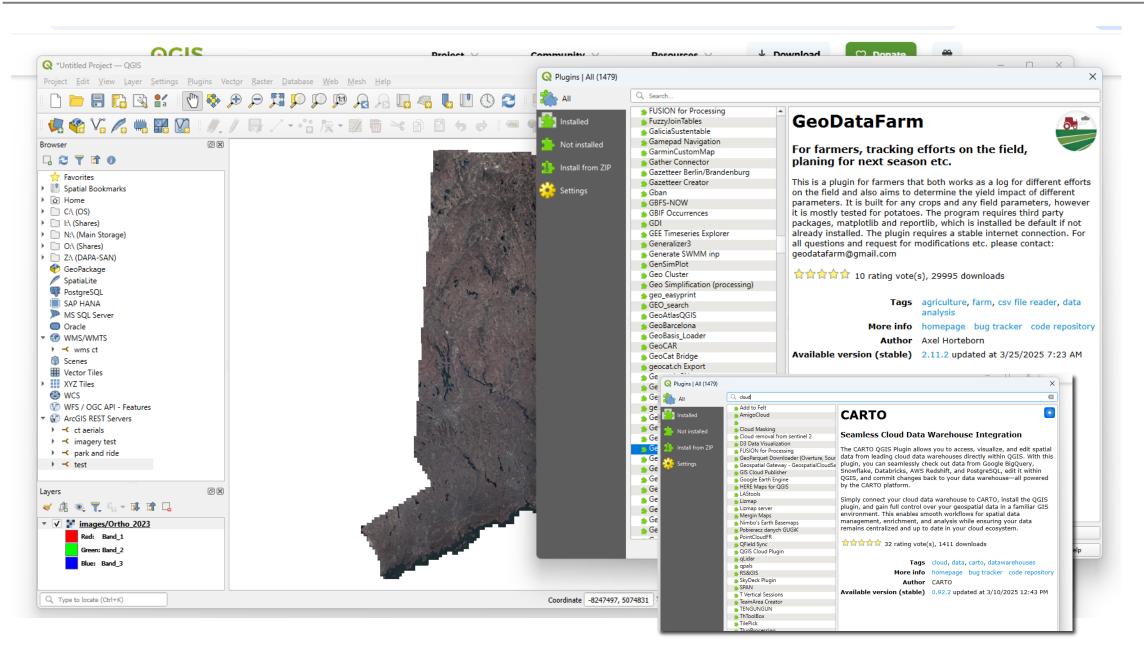
- GIS desktop applications
 - ArcGIS Pro (paid, \$100 for personal)
 - QGIS (free)
- Desktop oriented some limited web mapping capabilities
- Combine visualization and analytic functions
- Use to try out processes, experiment with data
- Single best choice for processing, viewing, and analyzing GIS data
 (ArcGIS Pro alternative)
- Mac/Linux, Windows, Android / Google
- Can be utilized with other code



Download QGIS Long Term Version/

QGIS Training Manual QGIS Tutorials







Desktop software: Grass GIS

Viki Loves Folklore	GRASS GIS	Photo Wikip	graph your local o edia and win!
Contents hide	Article Talk	Read Edit View history Tools V	Appearance hid
Top) Architecture	From Wikipedia, the free encyclopedia This article is about computer software. For plants growing in the ground, see Grass.		Text Small
History See also References Further reading External links	Geographic Resources Analysis Support System (commonly termed GRASS GIS) is a geographic information system (GIS) software suite used for geospatial data management and analysis, image processing, producing graphics and maps, spatial and temporal modeling, and visualizing. It can handle raster, topological vector, image processing, and graphic data. ^[2]	GRASS GIS	 Standard Large Width Standard
	GRASS GIS contains over 350 modules to render maps and images on monitor and paper; manipulate raster and vector data including vector networks; process multispectral image data; and create, manage, and store spatial data. It is licensed and released as free and open-source software under the GNU General Public License (GPL). It runs on multiple operating systems, including OS X, Windows and Linux. Users can interface with the software features through a graphical user interface (GUI) or by <i>plugging into</i> GRASS via other software such as QGIS. They can also interface with the modules directly through a bespoke shell that the application launches or by calling individual modules directly from a standard shell. The latest stable release version (LTS) is GRASS GIS 7, which is available since 2015. The GRASS development team is a multinational group consisting of developers at many locations. GRASS is one of the eight initial software projects of the Open Source	GRASS GIS graphical user interface Developer(s) GRASS Development Team Initial release 1984 Stable release 8.4.1 ⁽¹¹⁾ /25 February 2025; 30 days ago	 Wide Color (beta) Automatic Light Dark

Grass GIS for Windows/



Desktop software: Whitebox Software



Whitebox Software

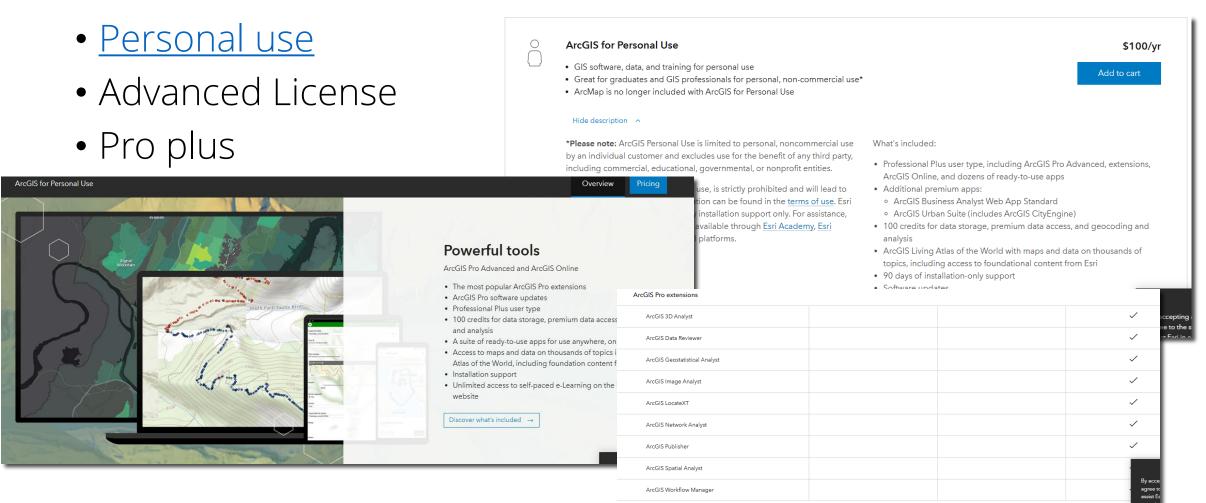
Whitebox Workflows for Python (WbW) WbW gives geospatial professionals **next-level geoprocessing functionality**, combining the Whitebox tools with Python scripting. Easily handle raster, vector, and LiDAR data from a single Python library. WbW is portable so you can **automate your workflows in any Python environment on any computer**. WbW is **freeware** and does not require users to purchase a license! All functions are also accessible from a convenient **QGIS plugin**.

Whitebox Workflows Professional (WbW- WbW-Pro adds the **75+ WTE extension tools** to the standard WbW product, making an even more powerful geoprocessing library for Python scripting. If you've used ArcPy, you're going to love WbW-Pro! And the two are easily integrated to streamline your geoprocessing. A single-user license is **\$500 and additional users are only \$100**. You

Whitebox Plugs into Pro or QGIS



Not quite free, ArcGIS Pro



Data & Policy Analytics

Takes anything: gvSig Destktop

- Highly interoperable
 - CAD , remote sensing, db, variety of web services
- gvSig Desktop Download

gvSIG Desktop

OSGeo



DOI 10.5281/zenodo.5869838

gvSig Desktop is easy to work in a variety of formats, vector and raster files, databases and remote services. There are always available all kinds of tools to analyze and manage your geographic information. gvSIG Desktop is designed to be an easily extensible solution, allowing thus continually improving the software application and developing tailor made solutions.



Limited AGOL (ArcGIS Online)

- Make basic web maps
- <u>ArcGIS Online Public Account</u>





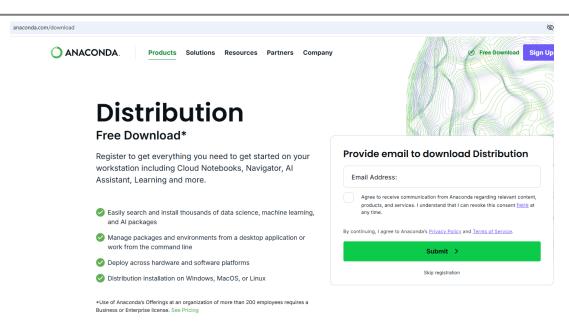
Scripting Tools

- Complicated
- Flexible and reliable
- Repeatable
- Growing
- Interoperable and linkable
- Often used in conjunction with commercial tools <u>and</u> underlies them
- Used in modern data science

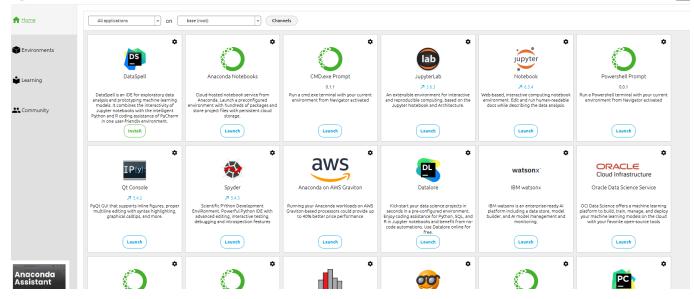


Anaconda

- Open-source software characteristics
 - Open and transparent code base
 - Updated continuously
 - Collaborative/community developed
- Organizes Python and R packages (really powerful!) and has updates ready for you (which is really important!)
 - Greatly simplifies loading and organization process



ANACONDA.NAVIGATOR



Upgrade Now

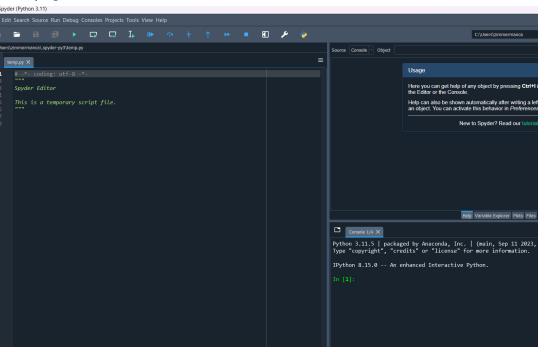


IDEs and Notebooks

• Jupyter notebooks

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Files Running Clusters	
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	Name Last Modified File size
Chapplications	a year ago
C C ArcGIS	a year ago
Contacts	2 years ago
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C Music	2 years ago
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OneDrive - State of Connecticut	8 hours ago
C Pictures	9 months ago
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• Spyder IDE



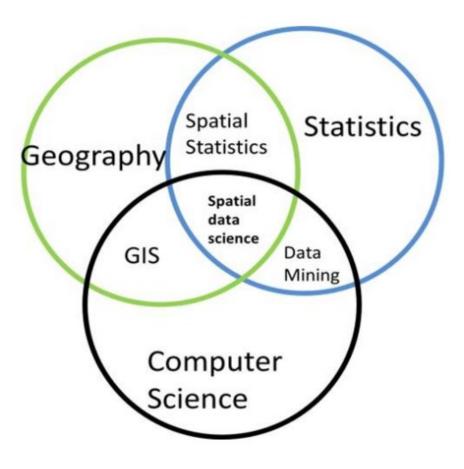
What is an IDE?

An IDE, or Integrated Development Environment, enables programmers to consolidate the different aspects of writing a computer program.



Types of GIS software

- Scripting (free)
 - Python (Geopandas, numpy, pandas)
 - R (tidy, ggplot2 or leaflet) ecosystems
 - Notebooks
- Allows for automation and workflow creation. Use when you need to repeat the process or integrate with other packages
- Lot of flexibility from source to output
- Scientific computing





Python GIS Libraries

- Geopandas/shapely-vector and overlay
- Rasterio-raster data
- GDAL-translation and conversion
- PyProj-projection
- Pandas/Numpy-statistics and munging
- Folium/ipyleaflet-interactive mapping in notebook
- PySAL-spatial statistcs
- ArcGIS API for Python (ArcPy)automation of ArcGIS tasks, data management

Geospatial Python/Spatial Data Science Ecosystem



37 Python Packages You Need for GIS

Found at: https://forrest.nyc/geospatial-needs-to-be-defined/



[1]: import pandas as pd import geopandas import matplotlib.pyplot as plt from geodatasets import get path

From longitudes and latitudes

First, let's consider a DataFrame containing cities and their respective longitudes and latitudes.

```
[2]: df = pd.DataFrame(
        {
            "City": ["Buenos Aires", "Brasilia", "Santiago", "Bogota", "Caracas"],
            "Country": ["Argentina", "Brazil", "Chile", "Colombia", "Venezuela"],
            "Latitude": [-34.58, -15.78, -33.45, 4.60, 10.48],
            "Longitude": [-58.66, -47.91, -70.66, -74.08, -66.86],
        }
}
```

A GeoDataFrame needs a shapely object. We use geopandas points_from_xy() to transform Longitude and Latitude into a list of shapely.Point objects and set it as a geometry while creating the GeoDataFrame. (note that points_from_xy() is an enhanced wrapper for [Point(x, y) for x, y in zip(df.Longitude, df.Latitude)]). The crs value is also set to explicitly state the geometry data defines latitude/ longitude world geodetic degree values. This is important for the correct interpretation of the data, such as when plotting with data in other formats.

[3]: gdf = geopandas.GeoDataFrame(

df, geometry=geopandas.points_from_xy(df.Longitude, df.Latitude), crs="EPSG:4326"

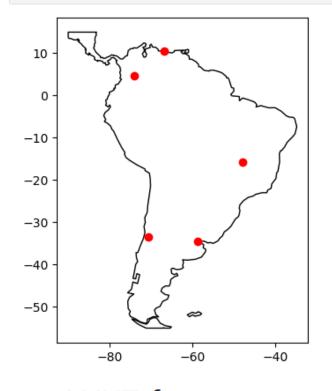
Finally, we plot the coordinates over a country-level map.

[5]: world = geopandas.read_file(get_path("naturalearth.land"))

We restrict to South America. ax = world.clip([-90, -55, -25, 15]).plot(color="white", edgecolor="black")

We can now plot our ``GeoDataFrame``.
gdf.plot(ax=ax, color="red")

plt.show()



gdf looks like this :



R and **GIS** libraries

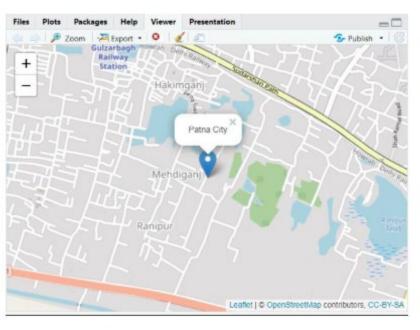
- Sf package overlay and other vector functions
- ggplot2 or leaflet -mapping
- Raster / rasterio/ rgdalworking with raster data
- Tidyverse- group of data science / visualization libraries know for their logic and ease of use

Tutorials and Background TidyVerse and Data Science Making Maps in R Crash Course in R Raster Data and R GeoComputation in R

Simple R Map

	library(leaflet)
ß	<pre>leaflet() %>% addTiles() %>%</pre>
÷ċ:	addMarkers(lng = 85.21, lat = 25.59, popup = "Patna City")

Output:





Types of GIS software

- Web mapping and dashboards
 - ArcGIS Online (free personal use/paid)
 - Tableau / Power BI (paid/free)
 - Dropchop.io (free web GIS)
 - Flexdashboard/Tidyverse
 - R dashboard variants
 - leaflet
- Web mapping is the least open-source friendly IMO

Web Mapping Servers

- Management software for deliver of web services
- <u>Mapserver</u> -delivers images of maps, relatively light
- <u>Geoserver</u>- supports transactional editing, more file formats

- Create web mapping services that can deliver content to users on websites
- Like ArcGIS Enterprise and AGOL

Brief Demos



- Basemaps
- Opening data from different sources
 - ArcGIS Rest Servers
 - GeoJSON
- Working with vector data
 - Attribute data
 - Quick spatial analysis
- Layouts (export maps as PDF or images)

A **project** is a container for all your map layers, properties, layouts, etc.

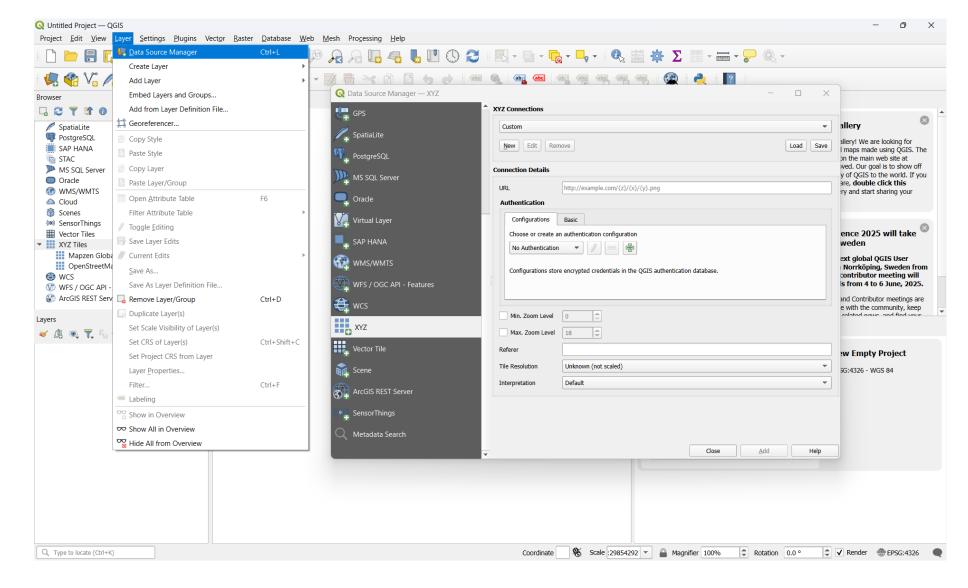
- Stores your layers, styles, coordinate systems, and symbology
- Keeps track of data paths (local files, services, URLs)
- Saves print layouts, labeling settings, and forms
- Lets you return to your work exactly as you left it

One project file = your workspace

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Ready-to-use XYZ Tiles services = Basemaps

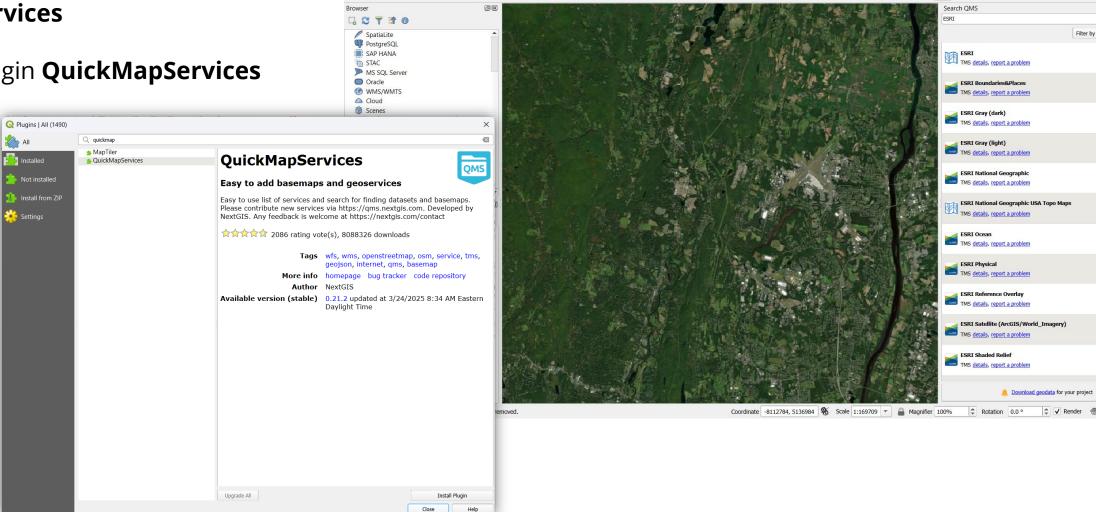


https://docs.qgis.org/3.40/en/docs/user_manual/managing_data_source/opening_data.html#using-xyz-tile-services



Ready-to-use XYZ Tiles services

Plugin QuickMapServices



Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help

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Load data from Web Sources:

Imagery

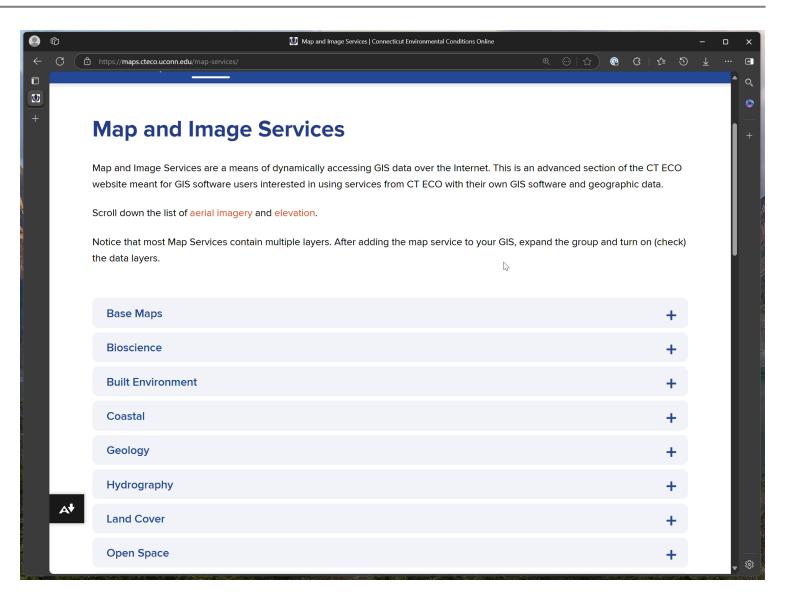
1. Go to: https://maps.cteco.uconn.edu/ map-services/

2. Get link:

https://cteco.uconn.edu/ctrast er/rest/services/

3. In QGIS:

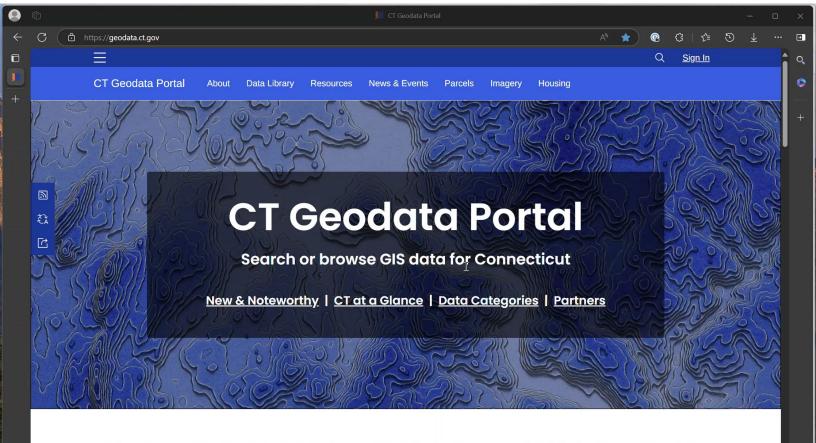
- Layer > Add Layer > ArcGIS REST Server
- Click New
- Name: CT Raster Server
- URL: Paste link
- Click OK
- Click Connect
- Explore datasets!





Load data from Web Sources:

<u>Vector data: GEOJSON</u> Municipal Boundaries

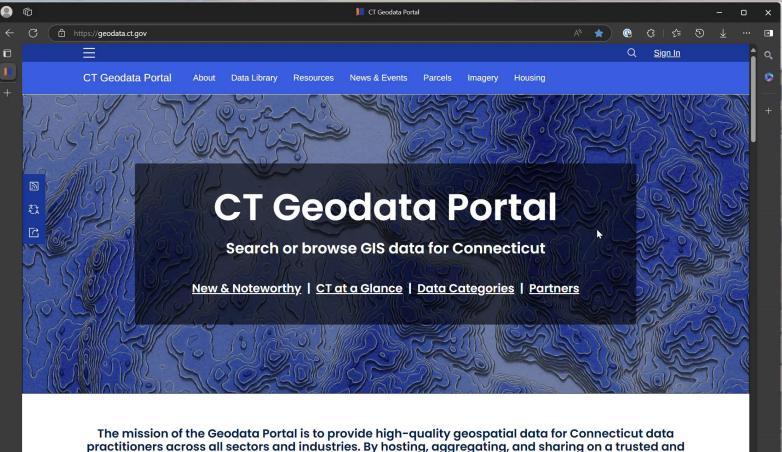


The mission of the Geodata Portal is to provide high-quality geospatial data for Connecticut data practitioners across all sectors and industries. By hosting, aggregating, and sharing on a trusted and reliable GIS open data platform, our users can expect to easily find and access valuable and trusted data resources.



Load data from **Web Sources**:

Vector data: ArcGIS REST Service Parcel Layer



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Working with **Vector Data**:

Queries on attributes Which parcels have a total assessed value higher/lower than or equal to X?

Which parcels are owned by X?

Q Query Builder	×
Set provider filter on Connecticut_CAMA_and_Parcel_Layer (provider: arcgisfeatureserver) Fields Values	
123 Appraised Outbuilding 123 Valuation Year 1.2 Land Acres abc State Use abc State Use Description 1.2 Model abc Condition Q Query Result The where clause returned 46712 rows.	All Query Builder × Set provider filter on Connecticut_CAMA_and_Parcel_Layer (provider: arcgisfeatureserver) Fields Fields Values
<pre> // Control Contr</pre>	abc Unit_Type abc Parcel_ID abc link abc Location abc Property City abc Owner abc Co_Owner
OK <u>T</u> est <u>C</u> lear <u>Save</u> <u>L</u> oad	<pre> Operators</pre>

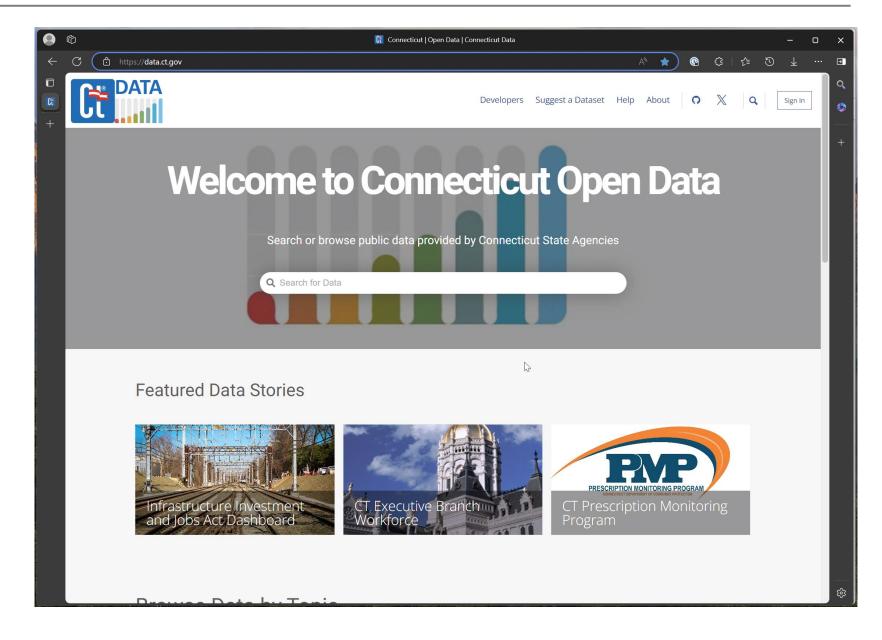


Working with Vector Data:

<u>Spatial analysis</u> w many bousebolds

How many households are within a 1-mile radius of each pharmacy?

Load *pharmacies* dataset (GeoJSON) from CT Open Data





Working with **Vector Data**:

Spatial analysis

How many households are within a 1-mile radius of each pharmacy?

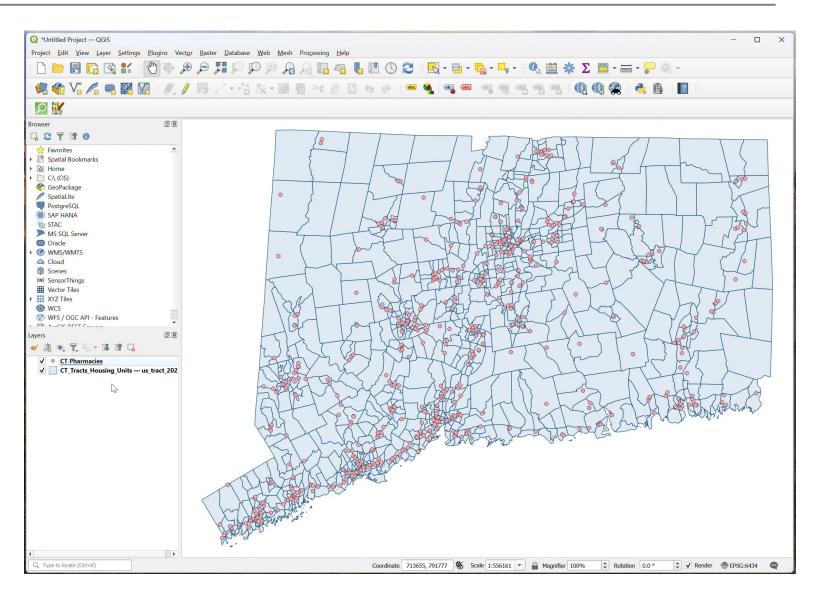
1. Create buffer

- Vector > Geoprocessing Tools > Buffer
- Distance: 1 mile
- Don't dissolve

2. Intersect (Select by location)

- Vector > Research Tools > Select by Location
- Features from: Tracts
- Compare to: Buffers

3. Export, symbolize, or analyze further data from those blocks!



Census data from: IPUMS National Historical Geographic Information System (NHGIS)



Working with **Vector Data**:

Spatial analysis

How many households are within a 1-mile radius of each pharmacy?

1. Open tract data attribute table

2. Field Statistics

- Right click on the housing counts field
- **Ensure you're applying it to selected features only**

3. View the sum of housing units

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	<u>A</u> nalysis Tools	► Sasic Statistics for Fields	
	<u>G</u> eoprocessing Tools G <u>e</u> ometry Tools <u>R</u> esearch Tools <u>D</u> ata Management Tools	 Sound Points in Polygon Line Intersections Mean Coordinate(s) Nearest Neighbour Analysis Sum Line Lengths Direct Advised 	
		 Distance Matrix List Unique Values 	
× (x)	•	 Vector Analysis - Basic Statistics for Fields Parameters Log Input layer Input layer Input tracts_housing_units_2023_5-year - ct_tracts_housin Input Selected features only Field to calculate statistics on 123 Housing_Counts Statistics (optional] [Create temporary layer] Input Statistics report [optional] [Save to temporary file] 	K Basic statistics for fields Generates basic statistics from the analysis of a values in a field in the attribute table of a vector layer. Numeric, date, time and string fields are supported. The statistics returned will depend on the field type.
2) : t			
	a Dias	0% Advanced Run as Batch Process	Run Close Help

Census data from: IPUMS National Historical Geographic Information System (NHGIS)



Working with **Vector Data**:

Spatial analysis

How many pharmacies are within 1mile radius of each census tract?

1. Processing (Toolbox):

- Join Attributes by Location (Summary)
- Input layer: Census Tracts
- Join layer: Pharmacy Buffers (1mile buffer layer)
- Choose Intersects
- Summaries to calculate: Check Count only
- •Run

vector Gel	neral - Join Attributes by	/ Location (Summary)						
Parameters	Log						۲	Join attributes b
Join to features	; in					•		location (summa
Selected fe Where the feat	atures only	ct_tracts_housing_unitsus_tr 💌	C	No.				This algorithm takes an input layer and creates a new vecto that is an extended version of input one, with additional attri in its attribute table.
 intersect contain equal touch 	 overlap are within cross 							The additional attributes and t values are taken from a secon vector layer. A spatial criteria applied to select the values fro second layer that are added to feature from the first layer in t resulting one.
		▼ fields) [optional]	ង	2				The algorithm calculates a star summary for the values from matching features in the secon layer(e.g. maximum value, m value, etc).
fid								
Summaries to o	alculate (leave empty to use	e all available) [optional]						
count								
Discard rec	ords which could not be joir	ed				•		
		0%						Cano
Advanced *	Run as Batch Process				Rur			Close Hel



Creating **Static Maps**:

<u>Layouts</u>

1. Create a Layout

• Project > New Layout > "Name"

2. Add your map

• Add item> Add Map > Draw Extent in Layout

3. Add a legend

Add item > Add LegendEdit!

4. Export

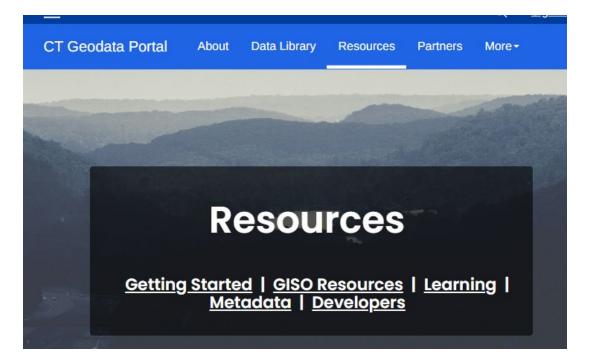
• Project > Export as ...

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Places to learn

- Interagency GIS (03/19/25)
- YouTube Videos
- ESRI
- <u>QGIS</u> Tutorials
- Academic Libraries
 - Brown University
 - <u>Tufts University</u>
 - <u>University of Minnesota</u>
- <u>Library of Congress</u>
- <u>CT Geodata Portal</u> and others
- Udemy, Coursera
- Call CT GIS Office





Questions???

• CT GIS Office

- Carl.Zimmerman@ct.gov
- Ashley.Benitez@ct.gov

- What tutorial topics do you want?
- Send us an email totalk about your ideas, projects, data, planning...

