Geospatial Problem Solving

Geospatial Software

Image from NASA: https://commons.wikimedia.org/wiki/File:Earth_Western_Hemisphere_transparent_background.png#filelinks

WV VIEW

AmericaView
Empowering Earth Observation Education
AmericaView.org - Est. 2003

This lecture provides an introduction to geospatial software.

Module Topics

1. GIS and geospatial software options
2. Code-based tools
3. Tools for web mapping
4. Graphic design software options
5. Use of AI in GIS/GISc
6. Installation process and navigating the ArcGIS Pro user interface
7. Installation process and navigating the QGIS user interface

2

These are the topics covered in this module.

Commercial Software

ArcGIS Pro

- Environmental Systems Research Institute (ESRI)
- First release in 2015
- Replaced older desktop software (ArcGIS Desktop)
- Fully functional desktop GIS
- Integrated into the ArcGIS software ecosystem

https://www.esri.com/en-us/arcgis/products/arcgis-pro/overviewb

4

In this course, we will explore the commercial ArcGIS Pro desktop GIS software created by the Environmental Systems Research Institute (ESRI). This software was initially released in 2015 and replaced the ArcGIS Desktop software suite. It is integrated with other ESRI products, including the web-based ArcGIS Online software.

Other Commercial Software

Global Mapper	https://www.bluemarblegeo.com/
ENVI	https://www.nv5geospatialsoftware.com/Products/ENVI
Erdas Imagine	https://hexagon.com/products/erdas-imagine
eCognition	https://geospatial.trimble.com/en/products/software/trimble-ecognition

5

There are other commercial geospatial software tools that will not be explored in this course. This slide provides a few examples.

Open-Source Software

Most open-source software is licensed under the MIT license or the GNU General Public License.

These licenses generally provide free access to the software and allow the user to use, copy, modify, merge, publish, distribute, and/or sublicense the software under certain conditions. This slide provides example language from the MIT license specifically.

Open Geospatial Consortium

- OGC
- Encourage development and implementation of open standards for geospatial content and services
- More than 30 standards supported:
  - SFS = Simple Features-SQL
  - WMS = Web Map Services
  - WMTS = Web Map Tile Services
  - WFS = Web Feature Services

https://www.ogc.org/

8

The Open Geospatial Consortium (OGC) serves as a curator of open standards in the geospatial sciences.

Commercial, government, nonprofit, and research organizations voluntarily collaborate to reach consensus on open standards.

The slide lists some of the common standards used in the geospatial sciences.

The Open Source Geospatial Foundation

https://www.osgeo.org/

- OSGeo
- Advocates for open software, data, education, science, and standards

9

The Open Source Geospatial Foundation supports and promotes collaborative development of open geospatial technologies and data.

OSGeo is involved in many projects including QGIS, GRASS, GDAL, and PostGIS.

QGIS

- GUI
- Integration with Python
- Integration with GDAL, GRASS, SAGA, and PostgreSQL/PostGIS
- Part of OSGeo Project
- Version 1.0 released in 2009
- Available for multiple operating systems

https://qgis.org/en/site/

10

In this course, we will primarily explore QGIS, as this is one of the most common and heavily used open-source GIS software packages. It also does not have a steep learning curve, since most tasks can be completed without coding or scripting.

QGIS has a graphical user interface (GUI) that is very intuitive. It is also available for use on multiple operating systems including Windows, Mac, and Linux.

Further, QGIS allows for the use of other open-source tools within its interface, including GRASS, SAGA, and GDAL.

GDAL

- Geospatial Data Abstraction Library
- Read and write vector and raster data
- Convert between raster and vector data formats
- Translate and process data
- Most open-source geospatial software rely on GDAL
- Initially released in 2000

https://gdal.org/

11

Many open-source and commercial geospatial software packages make use of the Geospatial Data Abstraction Library (GDAL). GDAL provides data standards for vector and raster spatial data.

The defined vector and raster data abstraction models allow for the use of data in a variety of formats and the conversion between data formats.

PROJ

- Formerly PROJ.4
- Open-source software/library for performing conversions between cartographic projections/coordinate systems
- Standard syntax for defining projections and coordinate systems
- Most open-source geospatial software rely on PROJ

https://proj.org/

Example PROJ Strings:

NAD83 UTM Zone 17N

```
+proj=utm +zone=17 +ellps=GRS80 +datum=NAD83 +units=m
+no_defs
```

US Contiguous Albers Equal Area Conic

```
+proj=aea +lat_1=29.5 +lat_2=45.5 +lat_0=37.5 +lon_0=-96
+x_0=0 +y_0=0 +ellps=GRS80 +datum=NAD83 +units=m
+no_defs
```

12

PROJ (formerly PROJ.4) is also used in many open-source and commercial software libraries.

It supports standards for defining geographic and projected coordinate systems and converting between specific systems.

PROJ strings offer a common text syntax for describing coordinate systems and their components, such as projection systems, datums, ellipsoids, origins, false eastings and northings, standard parallels and/or meridians, and units of measurement.

Example PROJ strings for the NAD83 UTM Zone 17 North and US Contiguous Albers Equal Area Conic projections are provide on the slide.

EPSG

- Provides a numeric code that references a coordinate system/projection
- European Petroleum Survey Group

NAD83 UTM Zone 17N

EPSG:26917

US Contiguous Albers Equal Area Conic

ESRI:102003

13

The European Petroleum Survey Group (ESPG) maintains a reference of geographic and projected coordinate systems.

Along with a PROJ string, coordinate systems are also assigned a unique EPSG code.

EPSG

http://spatialreference.org/

14

This slide provides a link to the Spatial Reference webpage that provides a standard resource for looking up and referencing different coordinate systems.

GRASS

- Geographic Resources Analysis Support System
- Integrated with QGIS
- Initially released in 1984

https://grass.osgeo.org/

15

The Geographic Resources Analysis Support System (GRASS) is integrated with QGIS and provides a variety of spatial analysis tools. Note that it can be used as a stand-alone application; however, we will only use it within QGIS in this course.

SAGA

- System for Automated Geoscientific Analysis
- Integrated with QGIS
- Wide variety of tools for raster analysis
- Initially released in 2004

http://www.saga-gis.org/en/index.html

16

Similar to GRASS, the System for Automated Geoscientific Analysis (SAGA) software is also integrated with QGIS and expands the functionality. It is used extensively for raster analysis and processing.

Similar to GRASS, it can be used in a stand-alone environment, which we will not explore here.

PostgreSQL and PostGIS

- Open-Source Relational Database
- PostGIS extends PostgreSQL for handling spatial data
- Integrated with QGIS
- Initially released 2001

https://www.postgresql.org/

https://postgis.net/

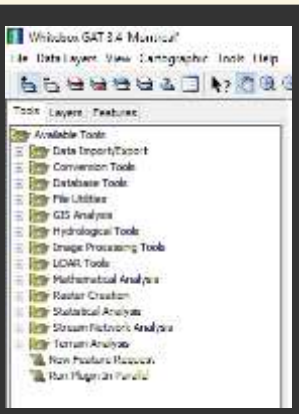
17

QGIS is well integrated with the free and open-source PostgreSQL relational database software. PostgreSQL is extended to handle geospatial data and processing using PostGIS.

One of the original uses of QGIS was to interface with PostgreSQL. For example, new data can be digitized in QGIS and saved directly to a PostgreSQL database.

WhiteboxTools and Whitebox GAT

- Over 440 tools for working with spatial data
- Whitebox GAT has a GUI
- WhiteboxTools accessed via QGIS, R, Python, or a command-line interface
- Created by Dr. John Lindsay (Geomorphometry & Hydrogeomatics Research Group; Geography, Environment & Geomatics; University of Guelph)



Whitebox
Geospatial Analysis Tools

https://jblindsay.github.io/ghrg/Whitebox/

WhiteboxTools

https://jblindsay.github.io/wbt_book/intro.html

https://jblindsay.github.io/ghrg/index.html

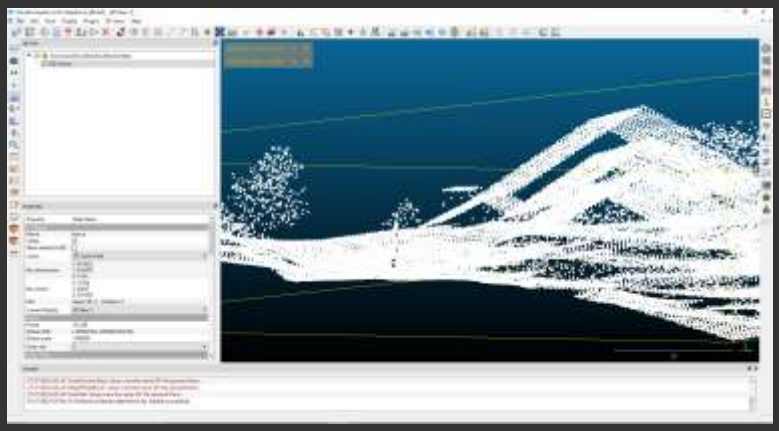
18

WhiteboxTools and Whitebox Geospatial Analysis Tools (GAT) provide more than 440 tools for analyzing geospatial data, including tools for data preparation, vector analysis and overlay, raster and image analysis, geomorphometric analysis, hydrological analysis, and LiDAR processing.

WhiteboxTools can be accessed in Python, R, QGIS, and via a command-line interface. They can also be accessed via a graphical user interface (GUI) known as Whitebox GAT. This toolset was developed by Dr. John Lindsay of the Geomorphometry & Hydrogeomatics Research Group at the University of Guelph.

CloudCompare

- For viewing and working with LiDAR/point cloud data



https://www.danielgm.net/cc/

19

CloudCompare allows for free viewing and manipulation of point cloud data, such as light detection and ranging (LiDAR) data sets.

Working in Code

Python for Data Science

- Python is used extensively in data science
- Relies on libraries: NumPy, Pandas, SciPy, MatplotLib, Seaborn, PyTorch, Scikit-Learn, Plotly, etc.
- Can use Anaconda distribution
- Many IDEs available: VS Code, IDLE, PyCharm, Spyder, Eclipse, PyDev, Atom, etc.
- QGIS and ArcGIS use Python

https://www.python.org/

https://www.spyder-ide.org/

https://www.anaconda.com/

21

The Python coding language is used extensively by data scientists and geospatial scientists. Python is integrated within ArcGIS Desktop and ArcGIS Pro via ArcPy. It can be used within QGIS via PyQGIS.

Python's data science capabilities rely on a variety of libraries including NumPy, Pandas, SciPy, and MatplotLib. Python is commonly installed using an Anaconda distribution, which allows for different environments to be established that contain different sets of libraries or even versions of Python. These data science libraries and Anaconda are also open-source and free.

You can use Python in ArcGIS or QGIS via the embedded Python console. However, there are other integrated development environments (IDEs) available. I generally use VS Code.

Python Packages for Spatial Analysis

- geopandas
- shapely
- Fiona
- rtree
- pyproj
- pyogio
- rasterio
- rioxarray
- earthpy
- whitebox
- torchgeo
- geemap
- leafmap

22

This slide lists some of the Python libraries that are used for geospatial data analysis and processing.

Python within ArcGIS Pro

- ArcPy
  - Run toolbox tools
  - Manage data
  - Map automation
  - Raster analysis
- ArcGIS Pro ships with a Python environment
- This environment can be cloned and modified
- ArcGIS Pro integrates notebooks
- ArcGIS API for Python = more for web GIS and server automation

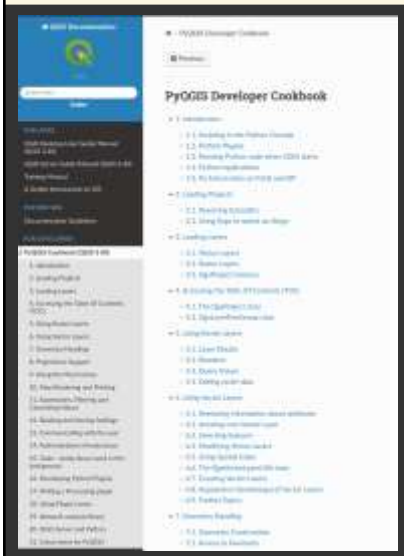
https://www.esri.com/en-us/arcgis/products/arcgis-python-libraries/libraries/arcpy

23

ArcGIS Pro has an associated Python package called ArcPy. There is also a separate ArcGIS API for Python, which is used primarily for web GIS and server automation tasks.

ArcGIS Pro install with a dedicated Python environment that can be cloned and modified. It also has integrated notebooks.

Python within QGIS



- PyQGIS

https://docs.qgis.org/3.40/en/docs/pyqgis_developer_cookbook/index.html

QGIS also has an associated Python package called PyQGIS.

R

- Statistical and data analysis software and language
- Used extensively in data science
- Many packages for working with spatial data
- RStudio IDE

https://www.r-project.org/ https://rstudio.com/

25

The R statistical and data analysis software and coding language is another powerful tool for geospatial professionals. We will not cover R in this course. However, it is explored in our *Methods in Open Science* and *Geospatial Supervised Learning* courses, which are available on our webpage. Note that RStudio provides an integrated development environment (IDE) for R.

R Packages for Spatial Analysis

- sf
- spatsat
- gstat
- tmap
- leaflet
- terra
- stars
- luna
- RSToolbox
- RSAGA
- rgee
- rpostgis
- rgrass
- qgisprocess
- whitebox
- RPyGeo
- r-bridge
- geodl


CRAN Task View: Analysis of Spatial Data

Maintainer: Roger Bivand, Jakub Nowosad, Krzysztof Dyba

Contact: Roger Bivand at nhh.no, nowosad.jakub at gmail.com, krzysztof.dyba at uni.lodz.pl

Version: 2026-01-24

URL: https://CRAN.R-project.org/view=Spatial

Source: https://github.com/cran-task-views/Spatial/

Contributions: Suggestions and improvements for this task view are very welcome and can be made through issue

Citation: Roger Bivand, Jakub Nowosad, Krzysztof Dyba (2026). CRAN Task View: Analysis of Spatial Da

Installation: The packages from this task view can be installed automatically using the ctv package. For exampl

https://cran.r-project.org/web/views/Spatial.html

26

This slide lists some R packages that support geospatial data analysis and processing. Specifically, sf is valuable for working with vector geospatial data while terra is central for working with raster geospatial data. tmap allows for creating map layouts.

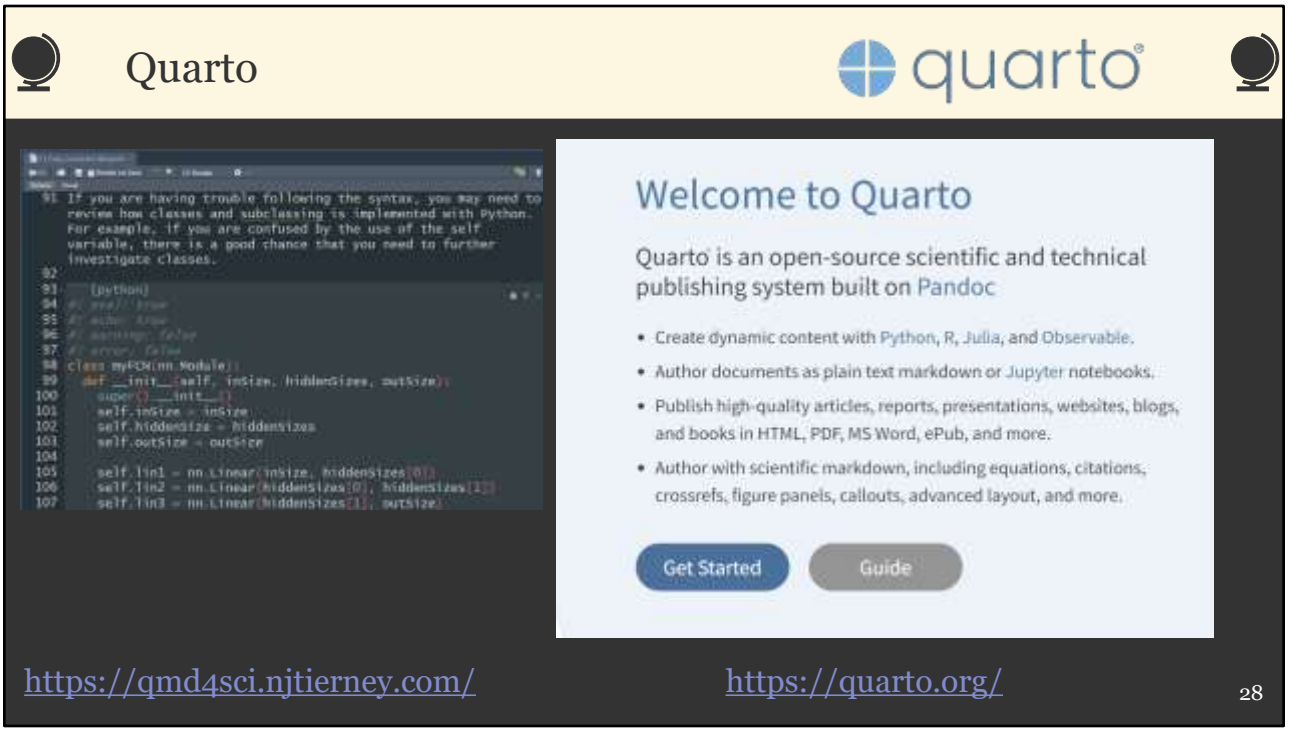
IDEs

- VS Code https://code.visualstudio.com/
- Google CoLab https://code.visualstudio.com/
- Spyder https://www.spyder-ide.org/
- RStudio https://posit.co/

https://posit.co/blog/three-ways-to-program-in-python-with-rstudio/

27

There are a variety of integrated development environments (IDEs) available for Python. I prefer either VS Code or RStudio, both of which are free. If you do not want to set up a local Python environment, you can make use of Google CoLab; however, there are usage caps. RStudio is my preferred IDE for R.



Quarto is a tool that allows for rendering code and Markdown to final products, such as PDFs, Microsoft Word documents, HTML webpages or websites, books, and presentations. If you want to learn more about Quarto, I recommend the free *Quarto for Scientists* test, which is linked at the bottom-left of the slide.

Web Mapping

ArcGIS Online

- Allows you to create maps and apps and host content for use on the Web
- Created by ESRI
- Integrated with ArcGIS Pro

https://www.arcgis.com/home/index.html

30

I will now provide an introduction to web GIS technologies. This is not a focus of this course; however, we have an entire course on this topic on the WV View website titled *Client-Side Web GIS*.

The ArcGIS Online platform provides web mapping capabilities and is produced by ESRI. It is integrated with ArcGIS Pro.

Survey123

- Generate surveys and forms
- Can be associated with spatial data

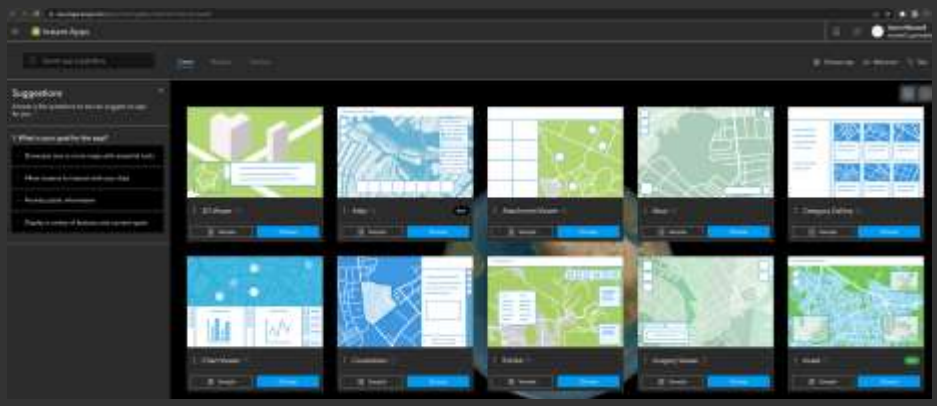
https://survey123.arcgis.com/

31

Associated with ArcGIS Online and ESRI products in general, Survey123 allows for creating and distributing surveys.

Presenting Your Data

- Instant Apps = pre-made applications that you can load your layers into



32

ArcGIS Online provides many options for generating web apps. For example, Instant Apps allow you to configure a template.

These are generally easy to set up and deploy; however, customization is limited.

Experience Builder

- Web-based tool for generating multi-page websites that do not need to be centered around a map

33

ArcGIS Experience Builder offers more customization than the Instant Apps. It is a tool to generate multipage websites with a variety of content. You don't even need to include geospatial data or maps; you could design an entire webpage without any maps or geospatial data or design pages with lots of maps. All this can be done without any coding.

ArcGIS Maps SDK for JavaScript

- Offers fully customizable web maps and apps (requires coding)

https://developers.arcgis.com/javascript/

34

The ArcGIS Maps Software Development Kit (SDK) for JavaScript allows for the generation of interactive web maps using JavaScript. It allows for a high level of customization; however, the user must have an understanding of the JavaScript coding language.

Leaflet

- Web map/app creation
- JavaScript API
- Some integration with QGIS and R

https://leafletjs.com/

35

Leaflet allows for the production of web maps and web apps using a JavaScript API. It is free and open-source. There is also integration with QGIS, Python, and R. Leaflet is explored in our *Client-Side Web GIS* course.

Graphic Design

Adobe Creative Cloud

- Photoshop = photo and raster
- Lightroom = photo management
- Illustrator = vector graphics
- Premiere = video
- Audition = audio
- Dreamweaver = websites
- XD = user interface development
- InDesign = page layouts
- After Effects = motion graphics and effects

https://www.adobe.com/creativecloud/pro.html

37

Graphic design software is also important in our field. This slide lists some of the Adobe products and their uses.

GIMP

- GNU Image Manipulation Program
- Free and open-source
- Image and raster editor

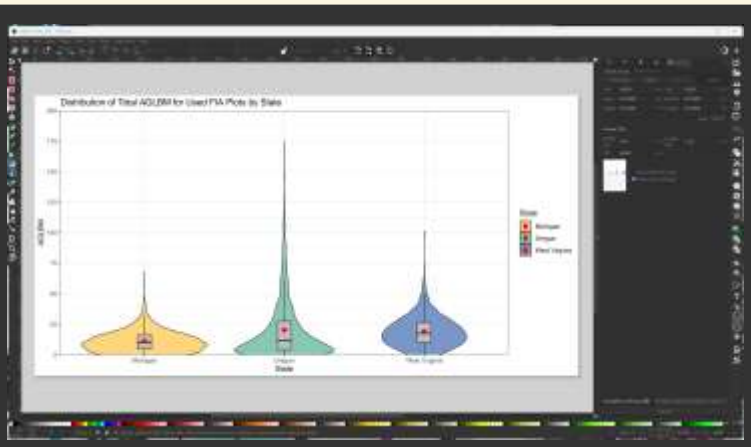
https://www.gimp.org/

38

GIMP is a free and open-source image or raster graphics editing tool. It performs tasks similar to Adobe Photoshop.

Inkscape

- Free and open-source
- Vector graphics editor



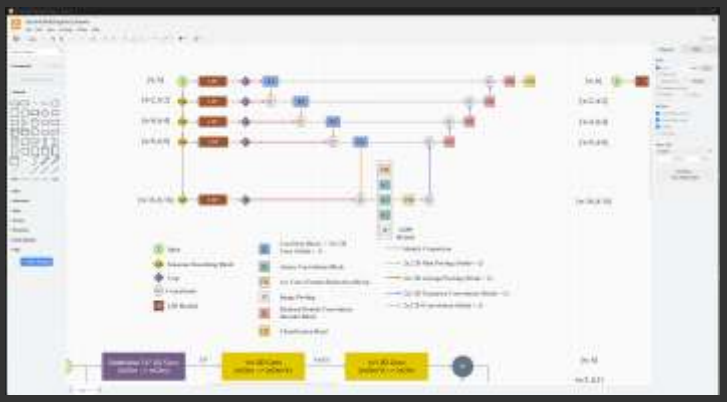
https://inkscape.org/

39

Inkscape is a free and open-source vector graphics editing tool. It performs tasks similar to Adobe Illustrator.

Draw.io

- Free and open-source
- Create flow charts and graphics



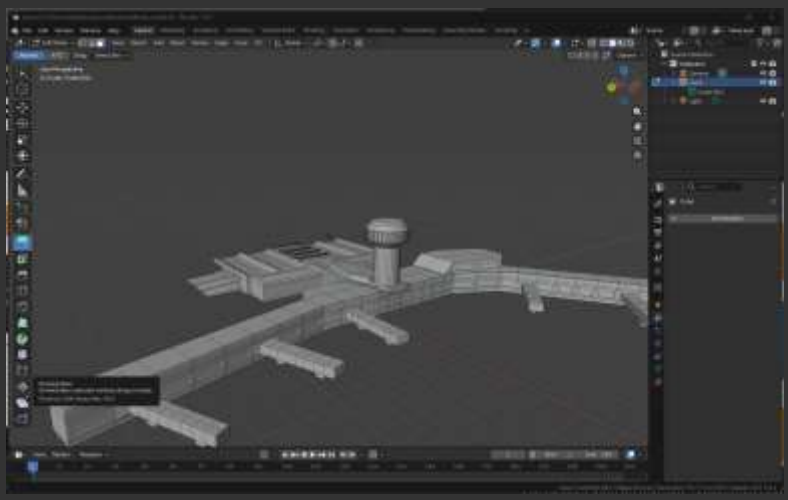
https://www.drawio.com/

40

Draw.io is a free and open-source tool for creating charts and diagrams. It can be used as a web-based or desktop app.

Blender

- Free and open-source
- 3D modeling
- 3D animation

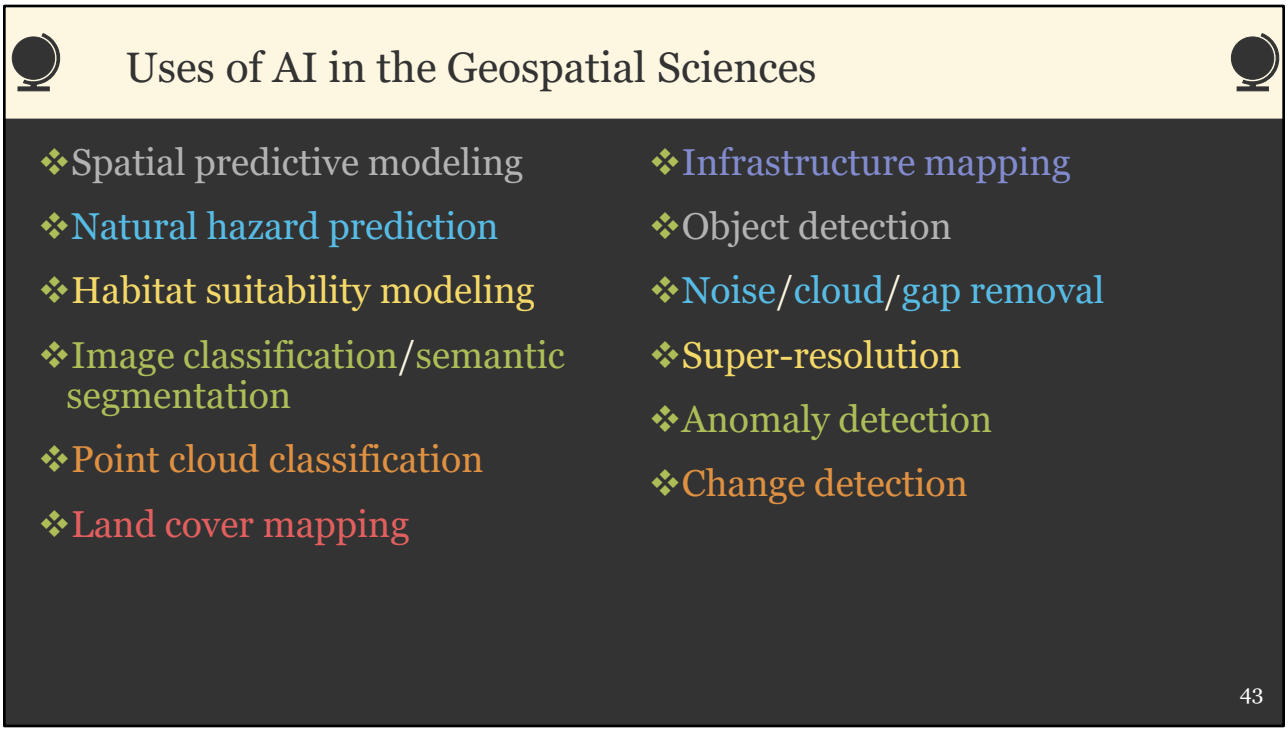


https://www.blender.org/

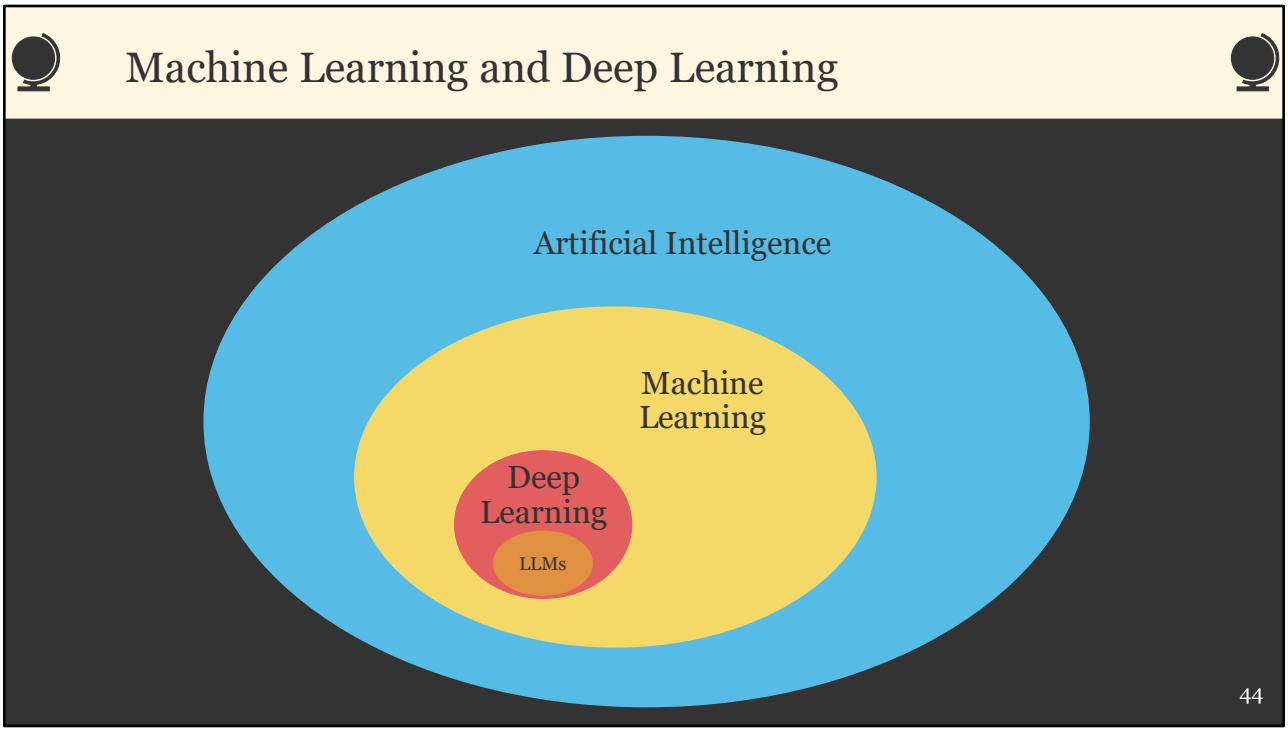
41

Blender is a free and open-source tool for 3D modeling, animation, and design.

AI and Large Language Models



Artificial intelligence (AI) has a wide variety of uses in the geospatial sciences.

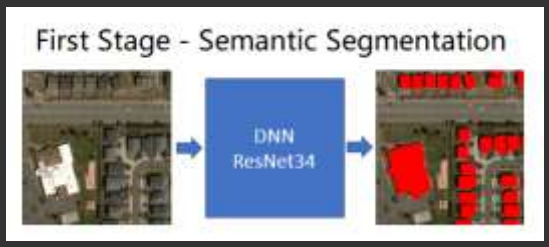


What is the difference between machine learning and deep learning? Deep learning is not different from machine learning. Instead, it is a special type of machine learning that relies on artificial neural networks with many hidden layers. Another common characteristics of deep learning methods is that model parameter updates are made using the backpropagation approach. In short, deep learning is a branch of machine learning.

There are many machine learning methods that do not make use of deep artificial neural networks, such as tree-based methods (e.g., decision trees, boosted decision trees, and random forests) and kernel-based methods (e.g., support vector machines).

There are also sub-types of deep learning, such as fully connected neural networks, convolutional neural networks, graph neural networks, and transformers.

https://www.nationalgeographic.org/funding-opportunities/grants/what-we-fund/ai-earth-innovation/

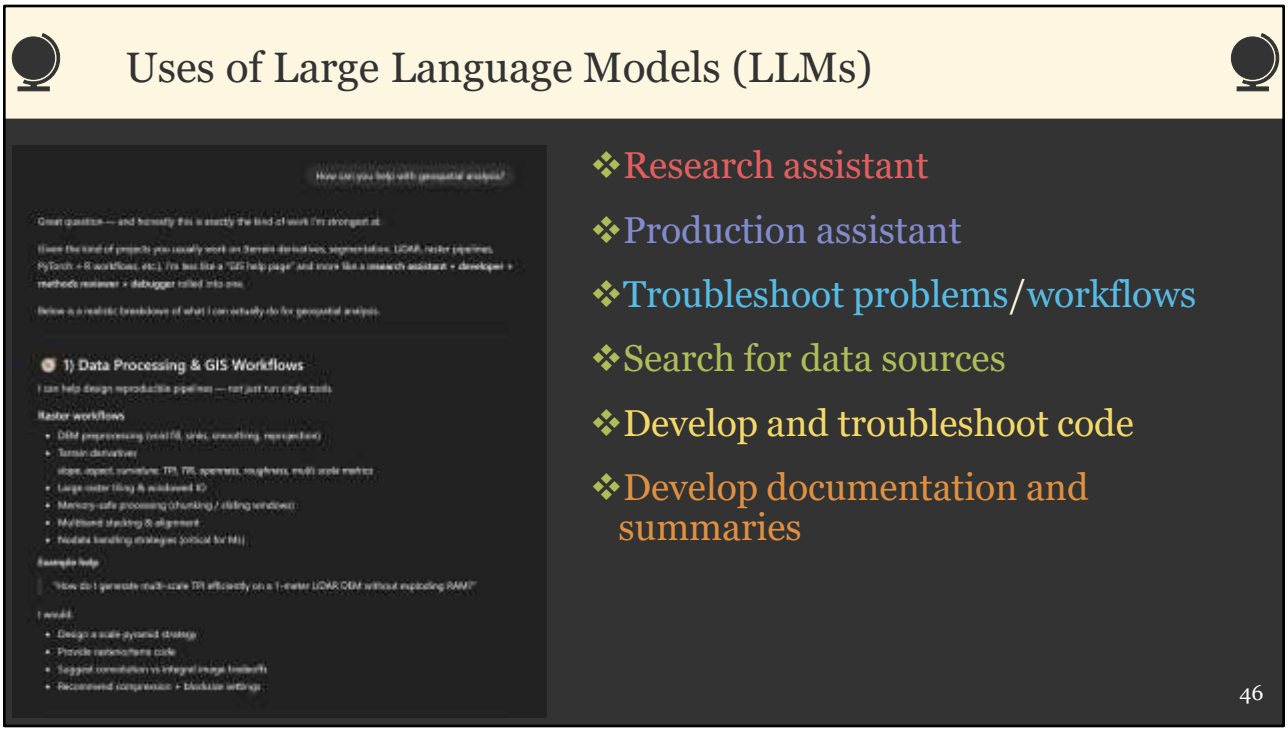


https://github.com/microsoft/USBuildingFootprints

https://azure.microsoft.com/en-us/blog/microsoft-and-esri-launch-geospatial-ai-on-azure/

http://lila.science/datasets/chesapeakelandcover

This slide provides some examples of geospatial deep learning projects. For example, Microsoft used deep learning techniques to map all buildings in the United States, a dataset that has been made freely available. Microsoft and the National Geographic Society offer grants yearly to individuals interested in applying deep learning to Earth observation data and other environmental data.



Large language models (LLMs) have a variety of uses in our field. As this technology is rapidly evolving, it is expected that their uses and adoption will continue to expand.

They can be used as a research or production assistant, to troubleshoot problems or software, for brainstorming new ideas, for generating and troubleshooting code, for explaining concepts, for helping with writing and grammar, and for helping with developing documentation and reports.

You can interact with LLMs via web and chat-based interfaces. It is also generally possible to upload files for the LLM to analyze or use as source material. Many tools also offer desktop installations that allow LLMs to interact with your local files and execute processes. They can also be installed and used within IDEs, such as VS Code, to help develop, troubleshoot, and document code.

LLMs are capable of generating output in a variety of formats including text, code, graphics and charts, images, video, 3D models, and audio.

LLMs Ethics and Etiquette

- Always disclose use
- You are ultimately responsible for the completeness, correctness, and suitability of your products, data, code, and analyses

47

You should always disclose the use of LLMs in your work. It is important to note that LLMs can make mistakes and generate inaccurate or misleading results (e.g., hallucinations). You are ultimately responsible for the completeness, correctness, and suitability of your products, data, code, and analyses.

Intro to ArcGIS Pro

ArcGIS Pro Software

- Developed by Environmental Systems Research Institute (ESRI)
- Modern commercial GIS software
- Integrated with web resources (ArcGIS Online)
- Expandable with extensions

https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview

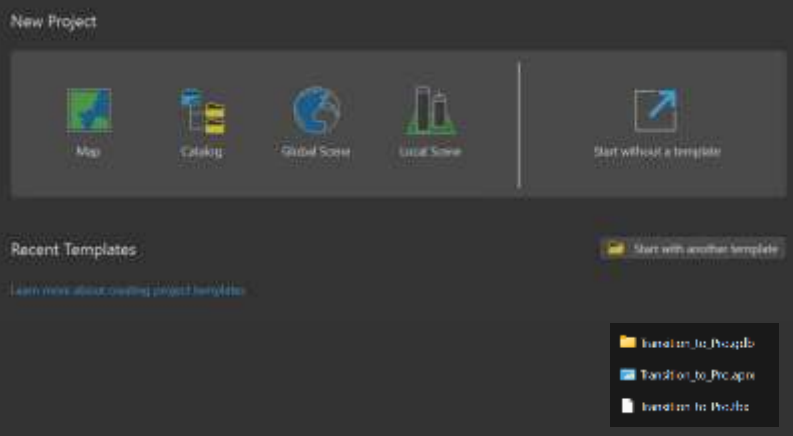
49

The following slides introduce the ArcGIS Pro software user interface (UI). It is a modern, 64-bit, tab-based software tool.

Create a New Project

- Project file = .aprx
- Project directory will include:
  - .aprx file
  - File Geodatabase
  - Toolbox (.tbx)
  - Logs/Index

Recommend starting with the Map or Catalog template in most cases. !



50

ArcGIS Pro projects are stored in project files (.aprx). When you create a new project, the .aprx file will be created along with a default file geodatabase (.gdb), toolbox (.tbx), and log/index folders in the specified file directory.

Tabs

- Project
- Map
- Insert
- Analysis
- View
- Edit
- Imagery
- Share
- Help
- Other tabs depending on what is active/selected

The Map tab is commonly our default tab. !

51

We will now discuss the different tabs that organize the software components.

Map Tab

- Copy/paste layers
- Navigate map
- Change base map
- Add data layers
- Select features
- Measure and locate

52

The Map tab provides tools for copying and pasting data layers, navigating within the map space, changing the base map, adding data layers to the map, selecting features from layers, making measurements, and locating features (coordinates, address, or places of interest).

Insert Tab

- Create new map, local scene, global scene, or base map
- Create new print layout
- Add/create new toolbox
- Add/create new Python Notebook
- Import maps and layouts
- Connect to databases/folders

53

The Insert tab is used to add new maps, scenes, or base maps to the project; create new map layouts; add, create, or connect to toolboxes; add, create, or connect to Python notebooks; import existing maps or layouts into the project; and connect to folders or databases.

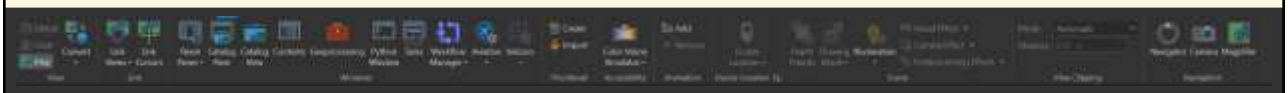
Analysis Tab

- See analysis history
- Access ModelBuilder
- Access Python Notebooks or console
- Change environment settings
- Access geoprocessing tools
- Links to commonly used geoprocessing tools and extensions
- Raster functions

54

The Analysis tab is used to access a variety of analyses. You can access ModelBuilder, Python Notebooks, the Python Console, geoprocessing tools, and raster functions. You can also change your processing environment settings. It provides a link to your analysis history, which keeps a record of all of the processes ran within the project. You can also open the Geoprocessing pane from this tab.

View Tab



- Convert between maps and scenes
- Link maps and/or scenes
- Activate windows and panes
- Color vision simulator
- Navigation, camera, and magnifier
- Scene illumination

55

The View tab is generally used to open windows or panes. It also allows you to covert between 2D maps and 3D scenes, link maps and/or scenes based on extent and/or scale, and simulate color vision differences. You can control the navigation, camera, and magnifier. For 3D scenes, you can change the illuminating conditions.

If you accidentally turn off a window or pane, you commonly can turn it back on from the View tab.

Share Tab

- Create packages (project, map, mobile map, layer, geoprocessing, deep learning)
- Save/share map and/or layers to web
- Share tools to web
- Copy to clipboard
- Export or print map layout

56

The Share tab allows you to make packages to share projects, data, maps, tools, or models. You can also publish maps or data to your ArcGIS Online content, copy the current map or scene view to your clipboard, and export maps or layouts to graphics files or for printing.

Help Tab

- Links to help resources

57

The Help tab provides access to online help resources, ESRI blogs, and technical support.

Map View

- 2D map
- Map scale
- Coordinates of cursor
- Count of selected features

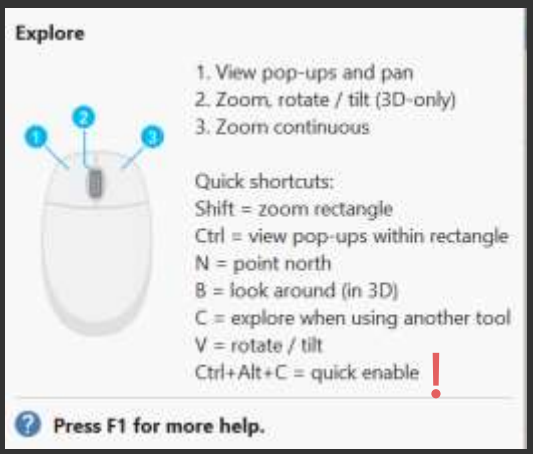
58

We will now discuss windows or views.

The Map view shows a 2D map. The margin provides information about the map scale, the current coordinates of the cursor, and the count of selected features.

Map Navigation

- Pan
- Zoom
- Full extent
- Zoom to selected
- Prior extent
- Next extent
- Bookmarks
- Go to XY



Navigation in ArcGIS Pro is much easier with a mouse.

59

This slide provides information about navigation within a 2D map space. Navigation options are provided under the Map tab in the navigation area. The largest image on this slide describes how to navigate using the mouse.

Note that Bookmarks allow you to save locations/extents to return to at a later time or to share with others.

Scene View

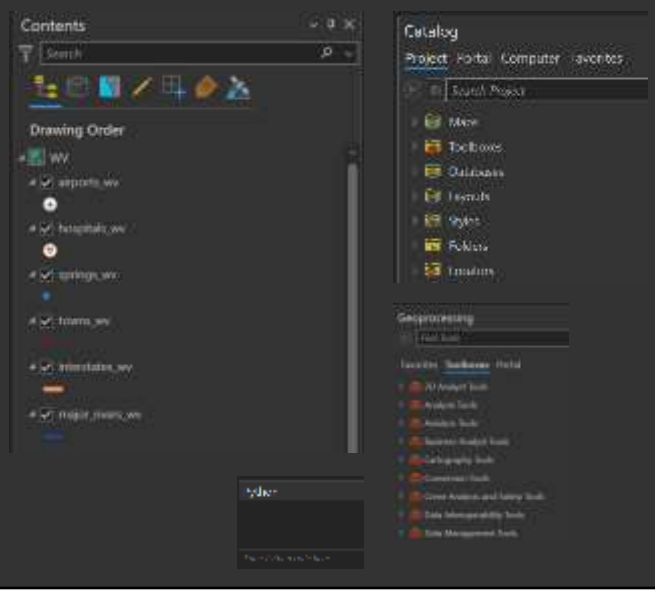
- 3D
- Simulate camera

60

In contrast to Map views, Scene views display data within a local or global 3D map using a simulated camera. Navigation controls will be different for a 3D scene vs. a 3D map.

Panes and Windows

- Contents = list of layers in map or objects in layout
- Catalog = access to maps, toolboxes, databases layouts, styles, folders, and locators (for file management)
- Geoprocessing = access to tools
- Python = type and execute Python code



61

Different panes or windows are available. This slide highlights some of the most common panes including Content, Catalog, Geoprocessing, and Python.

Contents Pane

- View layers by:
  - Drawing order
  - Data source
  - Selection
  - Editing
  - Snapping
  - Labeling
  - Perspective Imaging

We generally use drawing order by default, but Data source and Selection are also very useful.

From the Contents Pane you can:

1. Rename layer
2. Change visibility
3. Access symbology
4. Access layer properties
5. Access layer metadata
6. Navigate to layer
7. Open attribute table
8. Export layer
9. Etc.

62

The Content pane lists the data layers in the currently active map or scene. If you are working in a layout, it lists the elements included in the layout.

There are different means to list out the data layers, as described on this slide. I commonly use drawing order, data source, or selection. Drawing order lists the layers in their current drawing order, with the top-most layer in the list drawing on top of the layers beneath it. Data source separates the layers based on the geodatabase or directory in which they are stored. Selection lists the number of features selected per layer and allows you to make layers non-selectable.

You can right-click on a layer to open a pane to work with the specific layer. This pane provides options for renaming the layer, changing its visibility scales, accessing its symbology, viewing its layer properties or metadata, navigating to the layer, opening its attribute table, exporting a copy of the layer, and other layer-specific tasks.

Data-Specific Panes

- Symbology = change how layer is displayed
- Pop-Ups = change what attributes are display when layer is clicked
- Label = format feature labels

63

You can access several layer-specific panes by right-clicking on the layer in the Contents pane and using the pane that loads. The Symbology pane allows you to set and change the layer symbology. The Pop-ups pane allow you to configure a layer's pop-up, or what is shown when you click on the layer in the map or scene. You can also disable pop-ups. The Label pane allows you to configure labels. As with pop-ups, you can also disable labels.

Attribute Table View

- Right-click on layer in Contents Pane → Attribute Table

Attribute table view = each row is a record/feature; each column is some information about the record

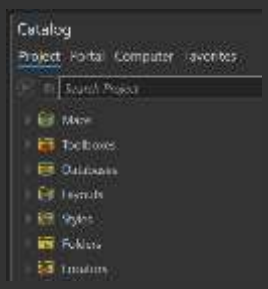
Field view = list of all columns and their associated characteristics

64

You can also open a layer's attribute table from the pane that loads when you click on a layer in the Contents pane. The Attribute Table view shows each record or feature and its associated attributes while the Field view lists the fields in the table and their associated characteristics, such as their alias names and data types.

Catalog View/Pane

- Maps = all maps/scenes associated with project
- Toolboxes = home toolbox + associated toolboxes
- Databases = home databases + associated databases
- Layouts = all print layouts associated with project
- Styles = styles/symbols
- Folders = home folder + associated folders
- Locators = geolocators



Add links to folders and geodatabases for easier access/navigation. !

65

The Catalog view or pane allows you to explore the assets associated with the project including maps, scenes, toolboxes, databases, layouts, styles, folders, and locators. You can also connect to new resources.

The Catalog can be accessed as a view or as a pane.

If a map or scene is not being shown in the current project, you can turn it on using the Catalog. You can also add connections to databases and folders for quick access.

General UI Tips

- Dark/Light mode
- Can dock/undock panes, windows, and views
- Drag to snap and dock
- Can undock to use multiple monitors
- Available tabs change with what is active/selected
- Can minimize and expand ribbon

66

This slide provides some general tips for working within the ArcGIS Pro UI.

Open ArcGIS Pro Project

1. Within your copy of the course data, navigate to data → day1.
2. Click on the day1.aprx file to open the project.

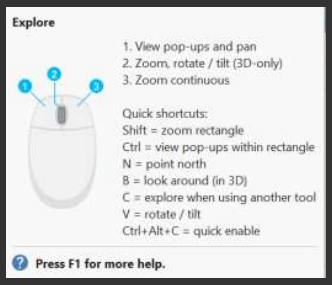
Make sure to uncompress provided data before use. !

67

This activity shows you how to open a project file.

Navigate in Map Space

1. Make sure the wv map is active.
2. Make sure the Map Tab is active.
3. Experiment with navigating within the map space.



ArcGIS Pro can be difficult to use without a mouse. Invest in a mouse. !

68

This activity asks you to navigate within a map.

Intro to QGIS

69

We will now explore QGIS.

Versioning

Version	Codename	Release Date
0.0.1-alpha		2002-07
1.0	Kore	2009-01-05
2.0	Dufour	2013-09-08
3.0	Girona	2018-02-23
3.2	Bonn	2018-06-22
3.4 LTR	Madeira	2018-10-26
3.6	Noosa	2019-02-22
3.8	Zanzibar	2019-06-21
3.10 LTR	A Coruña	2019-10-25
3.12	Bucureşti	2020-02-21
3.14	Pi	2020-06-19
3.16 LTR	Hannover	2020-10-23
3.18	Zurich	2021-02-19
3.20	Odense	2021-06-18
3.22 LTR	Białowieża	2021-10-22
3.24	Tisler	2022-02-18
3.26	Buenos Aires	2022-06-17
3.28	Firenze	2022-10-21
3.30	's-Hertogenbosch	2023-02-17
3.32	Lima	2023-06-23
3.34 LTR	Prizren	2023-10-27
3.36	Maidenhead	2024-02-23
3.38	Grenoble	2024-06-21
3.40 LTR	Bratislava	2024-10-25
3.42	Münster	2025-02-21
3.44	Solothurn	2025-06-20
4.0	Norrköping	To be released soon

- Help → About

LTR = Long Term Release

https://en.wikipedia.org/wiki/QGIS

70

QGIS follows a time-based release cycle, with a new version typically released every four months. During the first three months of each cycle, new features and improvements are actively developed. The final month is a feature freeze period, during which the focus shifts to testing, bug fixing, translation, packaging, and preparing the software for release. This approach allows QGIS to deliver new functionality on a regular schedule while still reserving time for quality control before each release.

QGIS also maintains a Long Term Release, or LTR, version. The LTR is intended for users and organizations that value stability over access to the newest features. While the current release provides the latest tools and improvements, the LTR receives ongoing maintenance and bug fixes for a longer period, making it a good choice for production environments, teaching labs, government agencies, and organizations that need a more stable software platform.

QGIS Versioning

- Long-Term Release (LTR)
  - Release once per year (February)
  - Bug fix updates for at least a year
  - Updates do not change features or interface
- Latest Release (LR)
  - Released every 4 months
  - Incorporates newly developed and tested features
- Developer (DEV, master, or testing)
  - Cutting-edge version
  - May have bugs

https://en.wikipedia.org/wiki/QGIS

Version	Codename	Release Date
0.0.1-alpha		2002-07
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3.10 LTR	A Coruña	2019-10-25
3.12	Bucureşti	2020-02-21
3.14	Pi	2020-06-19
3.16 LTR	Hannover	2020-10-23
3.18	Zurich	2021-02-19
3.20	Odense	2021-06-18
3.22 LTR	Białowieża	2021-10-22
3.24	Tisler	2022-02-18
3.26	Buenos Aires	2022-06-17
3.28	Firenze	2022-10-21
3.30	's-Hertogenbosch	2023-02-17

This slide further explains the QGIS release cycle.

Download and Install

- https://www.qgis.org/en/site/
- Windows, macOS, Linux, Android, iOS
- Standalone Installer
- OSGeo4W Installer

72

The link on this page provides access to the installation files for QGIS.

The standalone installer is the easiest option for a one-time QGIS installation because it bundles QGIS and its dependencies into a single installer. The OSGeo4W installer is more flexible and better suited for ongoing use because it allows users to install multiple QGIS versions, update individual components, and manage additional open-source geospatial packages. For beginners or short workshops, the standalone installer is often simpler; for regular users or managed environments, OSGeo4W is generally the better long-term choice.

Download and Install 2

- Standalone Installer
  - QGIS, GRASS, and SAGA
  - Specific release version
- OSGeo4W Installer
  - QGIS
  - Other tools
  - Dependencies
  - More flexible

This slide further explains the installation options.

Tour of GUI

- Browser
  - Navigate file directory
  - Connected to databases
  - Add data layers
- Layers
  - List of layers
  - Change symbology
  - Change drawing order
  - Turn layers on and off

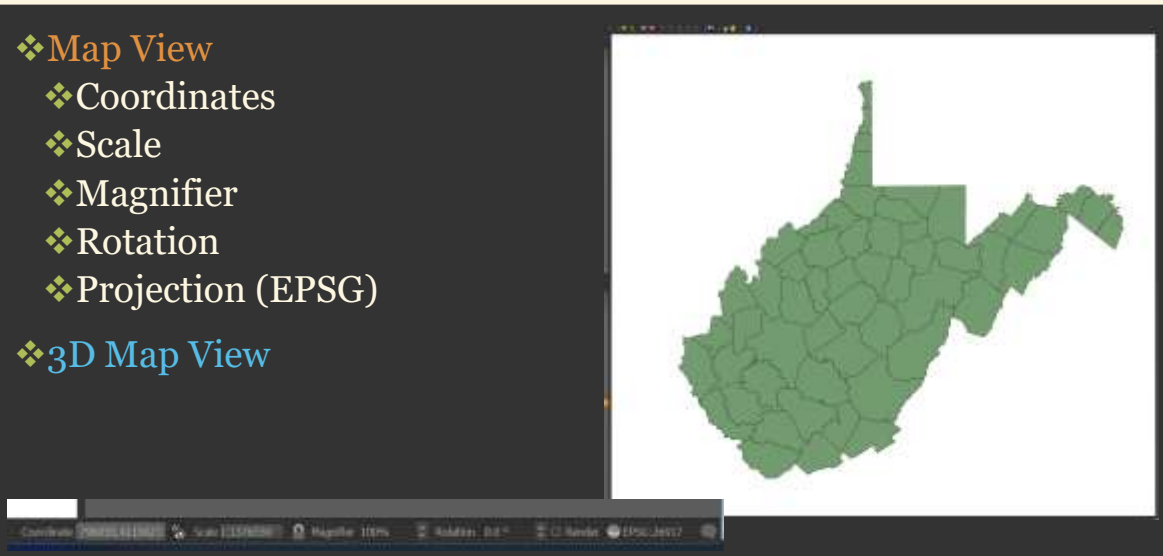
74

In the QGIS user interface, the Browser is similar to the Catalog in ArcGIS Pro. It allow you to search for and find layers to add to the map. You can also connect to remote data resources and servers.

Layers is similar to the Content pane in ArcGIS Pro. It lists the layers currently loaded into the map. Right-clicking on a layer opens a window that provides options for symbolizing and working with the layer along with obtaining information about the layer.

Tour of GUI 2

- Map View
  - Coordinates
  - Scale
  - Magnifier
  - Rotation
  - Projection (EPSG)
- 3D Map View



75

QGIS provides the Map view for 2D maps and also a 3D Map view for scenes. Margin information included with the map provides the current coordinates of the cursor, the map scale, access to a magnifier, rotation options, and the current map projection.

Tour the GUI

- Project → Open
- Project → New
- Project → Save
- Project → Save As
- Project → Properties
- Project → New Print Layout
- View → New Map View
- View → New 3D View
- View → Panels
- View → Toolbars
- Layer → Create Layer
- Layer → Add Layer
- Settings → Options
- Plugins → Manage and Install Plugins
- Processing → Toolbox
- Processing → Graphic Modeler
- Processing → History
- Processing → Results View
- Database → DB Manager

76

This slide lists some of the key options, tools, or windows/panes available under different menus in QGIS. In contrast to ArcGIS Pro, QGIS is currently a menu-based interface as opposed to a tab-based interface.

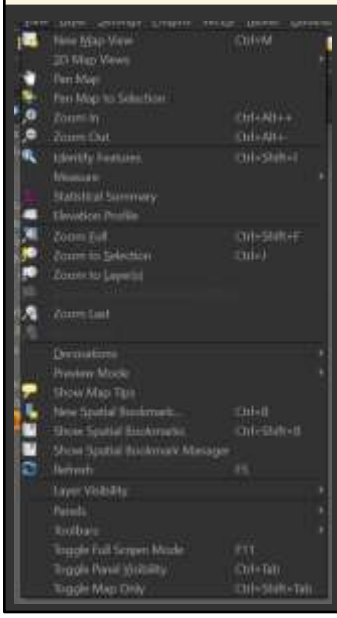
Processing Toolbar

- QGIS
- GDAL
- GRASS
- SAGA
- Some other installed plugins

77

The Processing Toolbar provides access to geoprocessing tools made available by QGIS, GDAL, and GRASS. SAGA tools have not been included natively in recent builds due to compatibility issues. Installed plugins may add additional tools.

Navigation



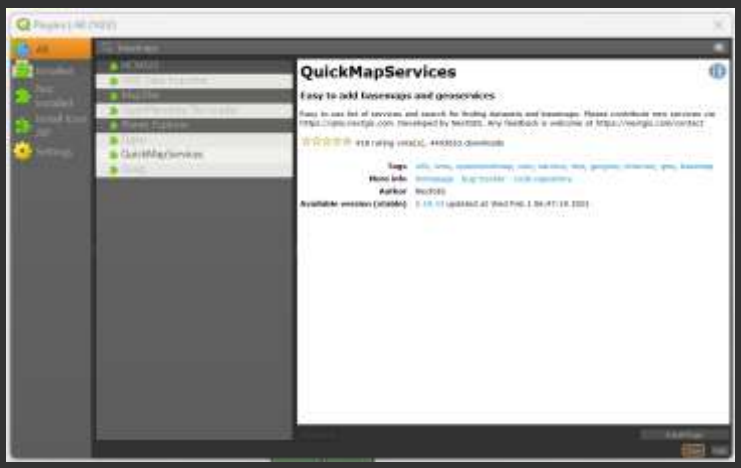
- Pan = Click, hold, move mouse/Arrow key
- Zoom In = Mouse wheel/Ctrl+Alt++
- Zoom Out = Mouse wheel/Ctrl+Alt+-
- Zoom Full = Ctrl+Shift+F
- Zoom to Selected = Ctrl+J
- Zoom Last
- Zoom Next

78

This slide explains navigation options within the map space.

Plugins

- Plugins → Manage and Install Plugins



You can install plugins to add additional functionality to QGIS.

QuickMapServices

- https://nextgis.com/blog/quickmapservices/

80

QuickMapServices is a great plugin that provides access to base maps.

Changing the Theme

- Load QSS – UI themes
- https://github.com/All4Gis/Load-QSS

81

The Load QSS – UI themes plugin provides access to a variety of UI themes for QGIS.

Package Recommendations

- qgis2web = QGIS to web map
- mmqgis = vector-based spatial analysis and geocoding
- Semi-Automated Classification = satellite image processing and classification
- Digitizing Tools = adds additional drawing and digitizing tools
- Point Sampling Tool = extract raster and polygon information at point locations

82

These are some recommended plugins for QGIS.

Orfeo Toolbox

- https://www.orfeo-toolbox.org/
  - Download OTB X.X.X
  - Choose operating system
  - Download, uncompress, move to preferred location
- In QGIS
  - Settings → Options → Processing → Providers
  - Set “OTB application folder” to the following subfolder in your Orfeo Toolbox folder: lib/otb/applications
  - Set “OTB folder” to your Orfeo Toolbox folder
  - Restart QGIS
  - Should now have OTB tools in Processing Toolbar

83

This slide describes how to install and link Orfeo Toolbox to QGIS. Orfeo Toolbox adds additional remote sensing functionality.

Open Project and Plugins

- Use the utah project.
- Install the following plugins using Plugins → Manage and Install Plugins: QuickMapServices and Digitizing Tools
- Add a base map to the map using QuickMapServices

84

This exercises asks you to open a project, install some plugins, and add a base map.

This is the end of this lecture module.

Please return to the West Virginia View Webpage for additional content.

Thanks! Hope you found this useful.