Geospatial Problem Solving

Finding Data

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 module will focus on finding geospatial data. Note that this will not be exhaustive. Instead, the goal will be to provide some general recommendations and suggestions.

Module Topics

1. Geospatial data sources
2. US national programs
3. Imagery data sources
4. Elevation data sources
5. Web services
6. Open data

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These are the topics covered in this module.

Common Data

1. Boundaries
2. Infrastructure (roads, railroads, power lines, pipelines, sidewalks, buildings, airports, train terminals, etc.)
3. Natural features (land cover, soil data, geology, climate data, water bodies, physiography, etc.)
4. Land ownership
5. Parcels
6. Census data
7. Imagery (aerial and satellite)
8. Digital elevation models (DEMs)
9. Contours
10. Topographic maps (Digital Raster Graphics)
11. Etc.

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This slide lists some of the common data types and datasets we use in GIS. Fortunately, many datasets are free and made publically available.

Means to Connect to Data

1. Download → Store locally
2. Download → Process → Store result
3. Connect to Service
4. Cloud Computing

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There are a variety of ways to access data. First, they can be downloaded and stored locally. Second, raw data can be downloaded, processed locally, and the results can be stored locally. Both of these options can be limiting when datasets are large. Third, it is possible to connect to data services and stream data layers into your desktop application. Note that the analyses that can be performed using such data can be limited. Fourth, it is also possible to access data using remote services and process these data using cloud computing resources.

West Virginia

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This section discusses data sources for West Virginia specifically.

West Virginia GIS Technical Center

- http://wvgis.wvu.edu/

The West Virginia GIS Technical Center provides statewide GIS services to advance the State's Spatial Data Infrastructure

A few of these services include the State Data Clearinghouse, a GIS People Directory, and the MapWV.gov web mapping portal

WV GIS Technical Center
WVU Department of Geology & Geography
330 Brooks Hall
P.O. Box 6300
Morgantown, WV 26506
Phone: (304) 293-0557
Fax: (304) 293-6522

http://wvgis.wvu.edu/data/data.php

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The West Virginia GIS Technical Center provides access to a wide variety of spatial datasets. If I am looking for data for areas within the state, I generally start here. One of the goals of the GIS Tech Center is to provides statewide GIS services to advance the state's spatial data infrastructure.

Most datasets can be downloaded from the website, unless they are too large.

WV GIS Tech Center Mission

1. Reduce duplication of data development efforts among organizations
2. Catalog and distribute GIS spatial data and information free-of-charge through the internet
3. Coordinate acquisition of new data additions to the West Virginia Spatial Data Infrastructure
4. Assist with strategic planning, development, and implementation of statewide mapping guidelines
5. Provide advisory services and training programs in the field of geographic information science
6. Conduct research and provide education towards improvement of geographic information technologies

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This slide provides the stated mission of the West Virginia GIS Tech Center.

WVGISTC Spatial Data Clearinghouse

- Over 300 unique datasets and 120 web services
- Valued at more than $70 million
- In 2023 the wvgis.wvu.edu webpage averaged over 53,000 views (i.e., page loads or reloads either from internal or external links) and 581 visits (i.e., landing on page from an external page) per day with over 19 million page views and 212,000 page visits for the entire year

https://wvgis.wvu.edu/data/data.php

The West Virginia GIS Tech Center's Data Clearinghouse provides a large set of downloadable data resources.

WVGISTC Web Maps and Services

- Publicly accessible gateway to essential base map layers and geoprocessing services
- In 2023 mapwv.gov had on average over 106,000 page views and 8,000 page visits per day with a total of over 38 million views and 2.9 million visits.
- The most visited app is the WV Property Viewer followed by the WV Property Assessment app
- Other key services/apps include the WV Flood Tool; WV Trail Inventory; and Hunting, Trapping, Fishing Map

https://www.mapwv.gov/

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They also make data available via streaming services and web map applications.

DEP TAGIS

- West Virginia DEP TAGIS
  - Mine permits
  - Oil and gas well data
  - LiDAR

https://tagis.dep.wv.gov/site/

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The West Virginia Department of Environmental Projection Technical Applications and GIS Unit, or TAGIS, provides access to mine permits, oil and gas well data, and LiDAR datasets. This is a good place to start if you are looking for data related to environmental regulation and resource extraction.

WVGES

- WVGES
  - Coal
  - Oil and gas
  - Marcellus data
  - Geology

http://www.wvgs.wvnet.edu/www/maps/maps.htm

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The West Virginia Geologic and Economic Survey provides data related to coal seams, oil and gas wells, Marcellus gas drilling, and geology.

Many other states have GIS centers or offices that centralize access to geospatial data.

National

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We will now discuss national-scale data resources for the United States.

Data for the US

Some national datasets:

1. US census TIGER data
2. National Hydrography Dataset (NHD/NHD Plus)
3. National Elevation Dataset (NED)
4. National Land Cover Dataset (NLCD)
5. Aerial Imagery
6. National Agriculture Imagery Program (NAIP)
7. Topographic Maps (DRGs)
8. Soil data (STATSGO/SSURGO)
9. National Wetland Inventory (NWI)

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Some public datasets are funded at the federal-level and are fairly consistent across the country.

US Data Sources

Source	Use	Importance
USGS The National Map	Elevation, hydrography, geographic names, boundaries, transportation, structures, land cover, orthoimagery	This is one of the most important U.S. base-data sources. USGS describes The National Map as providing foundational topographic layers including elevation, hydrography, names, structures, transportation, boundaries, land cover, and orthoimagery. (USGS)
U.S. Census TIGER/Line and cartographic boundary files	States, counties, tracts, block groups, roads, address-related geography, congressional districts, places	Key for demographic mapping and joining ACS/Decennial Census data to geography. The Census Bureau notes that 2025 TIGER/Line legal boundaries and names are current as of January 1, 2025. (Census.gov)
Data.gov / GeoPlatform	Federal open datasets across agencies	Data.gov is the U.S. government's open data portal and provides access to datasets from federal agencies; GeoPlatform harvests geospatial metadata from Data.gov. (Data.gov)
FEMA Flood Map Service Center / National Flood Hazard Layer	Flood insurance rate maps, flood zones, regulatory flood hazard products	FEMA identifies the Map Service Center as the official public source for flood hazard information produced for the National Flood Insurance Program. (FEMA Flood Map Service Center)
NOAA data portals	Weather, climate, oceans, coasts, severe weather, bathymetry, hazards	NOAA NCEI provides environmental data on weather, climate, ocean, coastal, and geophysical conditions; NOAA also provides GIS data for forecasts, radar, watches, warnings, hurricanes, and tsunamis. (NCEI)
EPA EnviroAtlas	Ecosystem services, environmental exposure, health-related environmental indicators	Good for applied environmental GIS examples. EPA describes EnviroAtlas as a web-based tool providing geospatial data and resources related to ecosystem services, stressors, and human health. (US EPA)
State GIS clearinghouses	Parcels, roads, address points, local boundaries, wetlands, land use, imagery	Often more detailed than federal sources. Examples: state GIS portals, state DOT data, state environmental agencies, state geologic surveys.
County and municipal open data portals	Parcels, zoning, buildings, address points, utilities, local roads, permits	Best for local planning, cadastral, zoning, and municipal infrastructure topics.

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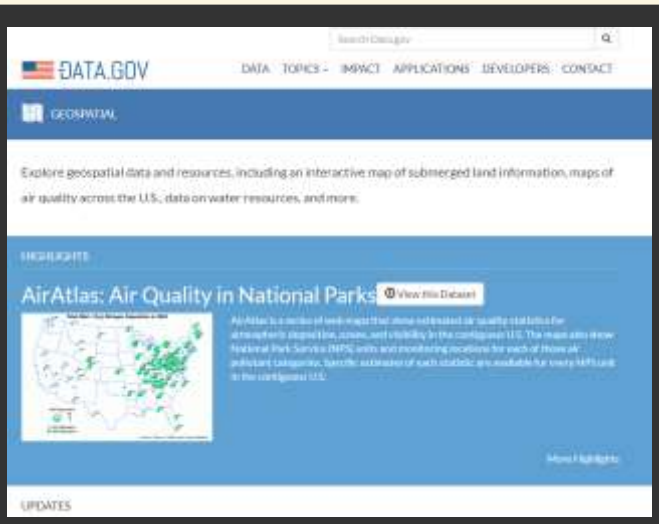
This table describes some key geospatial data resources for the United States. Some of these resources are discussed in the following slides.

Data.gov



https://www.data.gov/geospatial/

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Data from the US federal government, including geospatial data, are made available through Data.gov. This is a good place to start to look for data for the country or areas within the US.

NRCS Geospatial Data Gateway

- https://gdg.sc.egov.usda.gov/

https://datagateway.nrcs.usda.gov/

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I also like the United States Department of Agriculture Natural Resource Conservation Service Geospatial Data Gateway. This is a great source of environmental data relating to climate, elevation, soils, geology, watersheds, and land cover. It also provides access to political boundaries and US Census data. Additionally, you can download USDA orthophotography. I have found this site to be very intuitive and easy to use.

Data for the US

- National Map
  - Geographic names
  - Elevation
  - Orthoimagery
  - Land cover
  - Topographic maps
  - Hydrography (surface water)
  - Transportation
  - Structures
  - Public land
  - Government units

http://nationalmap.gov/

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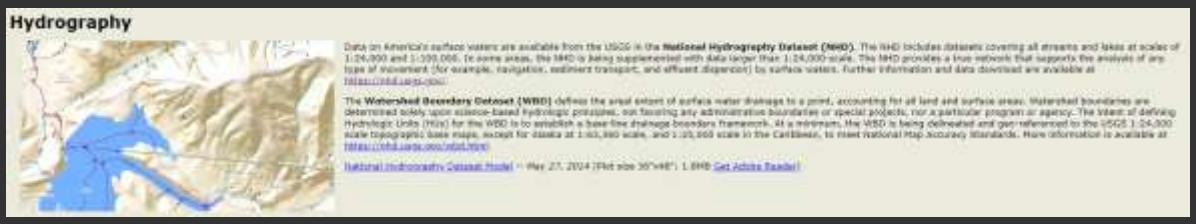
The National Map provides access to many data layers as listed above. Data can be downloaded using an interactive web map.

Hydrography

- National Hydrography Dataset
- Watersheds Boundaries Dataset



https://nhd.usgs.gov/

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Hydrography in the United States is made available through the National Hydrography Dataset. This dataset models the surface water features at different scales across the country. The data are topologically correct so that network analysis can be performed through the drainage system. The NHD data include lakes, ponds, streams, rivers, canals, dams, and stream gages. The Watershed Boundary Dataset defines the areal extent of drainage basins or watersheds at different scales. The scales are defined relative to the Hydrologic Unit Code system, or HUC, system.

The National Hydrography Dataset, or NHD, is the primary U.S. vector dataset for mapping surface-water features such as streams, rivers, canals, lakes, reservoirs, wetlands, springs, dams, and stream gages. Earlier medium-resolution versions were based on more generalized 1:100,000-scale hydrography, while the high-resolution NHD uses 1:24,000-scale or better source data and provides more detailed local hydrography.

The Watershed Boundary Dataset, or WBD, complements the NHD by providing HUC-based watershed boundaries.

NHDPlus Version 2 extended the older NHD by adding catchments, flow estimates, stream order, network connectivity, and other value-added attributes for hydrologic modeling, but it was based on older 1:100,000-scale

data.

NHDPlus High Resolution provides a more detailed analysis-ready hydrography framework by combining high-resolution NHD, WBD, and 3DEP elevation data.

The newest effort, the 3D Hydrography Program, or 3DHP, is modernizing national hydrography by deriving and aligning water features with high-quality elevation data, creating a more terrain-consistent hydrographic framework for future GIS and hydrologic analysis.

Soil Data

STATSGO = General state-level data (State Soil Geographic Database)

SSURGO = Specific county-level data (Soil Survey Geographic Database)

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053629

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Soil data in the United States are provided by the STATGO and SSURGO products. STATSGO represents more general state-level soil data whereas SSURGO represents more specific county-level data. SSURGO data are a digital versions of county-level soil surveys.

National Land Cover Database (NLCD)

- Land cover, land cover change, impervious surface, canopy cover
- 1985 to 2024
- http://www.mrlc.gov/

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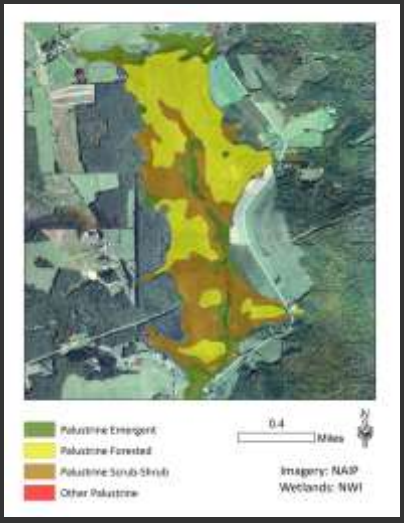
The National Land Cover Database, or NLCD, is a national land cover dataset for the United States produced by the Multi-Resolution Land Characteristics Consortium. It provides consistent, wall-to-wall land cover information for the conterminous United States and, for some products, Alaska, Hawaii, and U.S. territories. NLCD maps the landscape into thematic classes such as developed land, forest, shrubland, grassland, cultivated crops, wetlands, and open water. The dataset is commonly used in GIS and remote sensing for land cover mapping, environmental modeling, urban growth analysis, habitat assessment, watershed studies, and change detection. NLCD products are derived primarily from Landsat satellite imagery and are generally provided at a 30-meter spatial resolution, making them useful for regional to national-scale analysis rather than fine-scale site mapping. In addition to categorical land cover, NLCD also includes related products such as percent developed impervious surface and tree canopy cover. Because NLCD is produced using a consistent classification system across multiple time periods, it is especially valuable for analyzing how land cover has changed over time.

Data are available annually from 1985 to 2024.

National Wetland Inventory (NWI)



https://extension.unh.edu/resources/files/Resource001874_Rep2718.pdf

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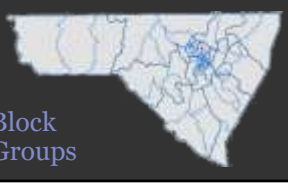
Wetland data are provided by the National Wetland Inventory or NWI. The quality of these data vary across the country. They were primarily generated from aerial image interpretation. Multiple wetland types are differentiated.

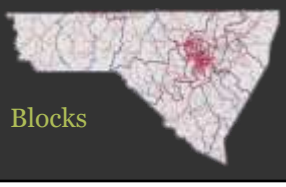
Census Data 1

- Decennial census
- Data collected
  - Population counts
  - Demographic data
  - TIGER/Line vector data (roads, other) (Topologically Integrated Geographic Encoding Referencing)
- Geographic units for Census
  - State > County > Tract > Block Group > Block
  - Populated places (Census designated places)
  - Urban areas/MSAs

Tracts



Block Groups



Blocks

https://www.census.gov/geo/maps-data/data/tiger.html

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A variety of data layers are made available by the US Census, which is conducted every ten years. Examples include population counts, demographic data, and vector data representing roads. Census results are aggregated to different units, including states, counties, tracts, block groups, and blocks. They also map populated places and urban areas.

Census Data 2

- Decennial Census data include vector line datasets (roads) and population counts at different levels of geography (county, tract, etc.)
- You can also obtain historic census data
- Can get data related to labor, employment, crime, health care, and income
- Can get tabular data and spatially join it to boundaries
- American Community Survey (ACS)

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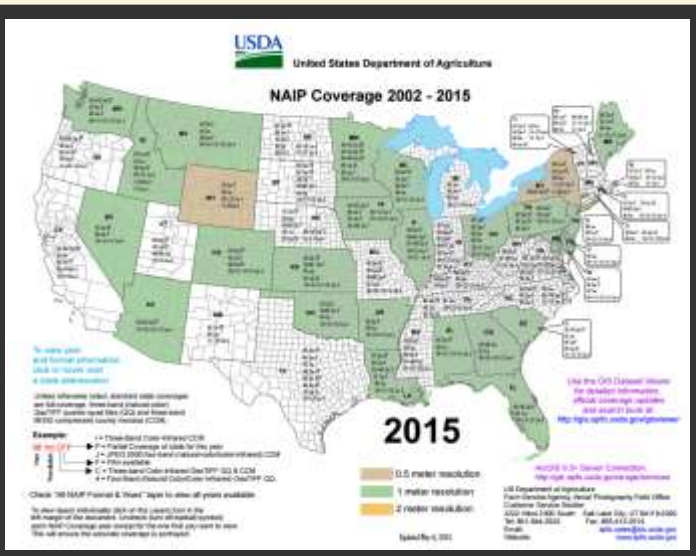
Since the census is conducted on a regular and repeating basis, it is possible to compare change over time. Data are made available relating to labor, employment, crime, health care, income, population, demographics, housing, social factors, educational attainment, and economics. The US Census is a key data source in the country.

The Census also generated data sets know as the American Community Survey (ACS) to make estimates between the decennial census.

National Agriculture Imagery Program (NAIP)



https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/APFO/NAIP_Covg_20150512.pdf

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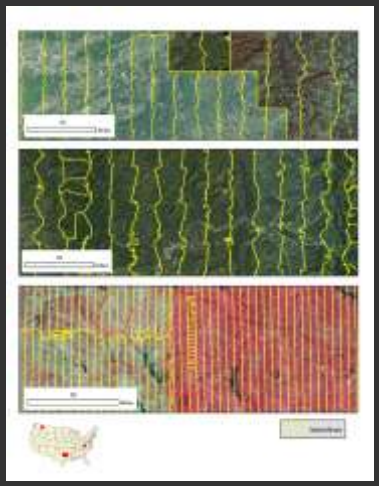
One aerial orthophotography dataset that is currently made freely available in the United States is the National Agriculture Imagery Program or NAIP orthophotography.

These image collections are contracted by the US Department of Agriculture.

National Agriculture Imagery Program (NAIP)

- State coverages
- Collected every three years (often more frequently)
- 3-band or 4-band
- 1 m cell size
- Growing season conditions



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The NAIP data are generally collected for entire states every 2 or 3 years. Older data were collected as 3-band true color images or 4-band CIR images. Recently, most data have been 4-band CIR images collected with digital sensors.

NAIP data have traditionally been provided at a 1-meter spatial resolution. However, more recently higher resolution data have been collected.

These data are generally collected during the growing season and represent leaf-on conditions. This is because their primary purpose is for agricultural monitoring. Data are not commonly collected during the winter or during leaf-off conditions.

The imagery is generally made available at orthophotographs by USGS quarter quads or as county mosaics.

International

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We will now explore datasets that are available across the entire globe or for areas outside of the United States.

International Data Sources

Source	Best for	Importance
Natural Earth	Small-scale global countries, admin boundaries, rivers, populated places, physical features, shaded relief	Excellent for cartography and global reference maps. It is public domain and available at 1:10m, 1:50m, and 1:110m scales. (Natural Earth)
OpenStreetMap	Roads, buildings, POIs, land use, amenities, trails, local features	Great for comparing volunteered geographic information with authoritative data.
Overture Maps	Global open map data, places, transportation, buildings, base layers	Good modern example of cloud-native open map infrastructure. Overture describes itself as free and open map data with modular schemas and stable IDs. (Overture Maps Foundation)
United Nations GeoHub / UN geospatial resources	Global administrative, humanitarian, reference, and thematic datasets	Useful for global governance, humanitarian mapping, SDGs, and international data infrastructure. The UN GeoHub is described as a gateway to data, maps, web services, and references across the UN system. (Geo Hub)
ArcGIS Living Atlas of the World	Ready-to-use global and regional layers, web maps, apps, imagery, demographics, hazards	Useful in Esri-based classes because students can quickly add authoritative or curated layers. Esri describes it as a collection of geographic information from around the globe, including maps, apps, and data layers. (Living Atlas)

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This table summarizes some globally available data sources.

Natural Earth

- Provides open-source data for small scale maps (1:10M, 1:50M, 1:110M)

https://www.naturalearthdata.com/

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One good source of general base map data for smaller scale maps are the data provided by Natural Earth, which are free and open-source. However, Natural Earth should still be cited when these data are used.

Finding Data Internationally

https://inspire.ec.europa.eu/

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This slide provides a link to the INSPIRE page made available by the European Commission. INSPIRE stands for Infrastructure for Spatial Information in Europe. This site provides data standards across European countries and offers a wide variety of data including administrative units, transportation networks, natural risk zones, and elevation.

Finding Data Internationally

https://www.eionet.europa.eu/gis/

https://www.nrcan.gc.ca/earth-sciences/geography/topographic-information/free-data-geogratis/11042

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This slide provides example resources for Europe and Canada.

Finding Data Internationally

https://www.openstreetmap.org/

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

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OpenStreetMap provides access to free and open crowd-sourced data.

The provided Wikipedia link lists GIS data sources across the globe.

Imagery

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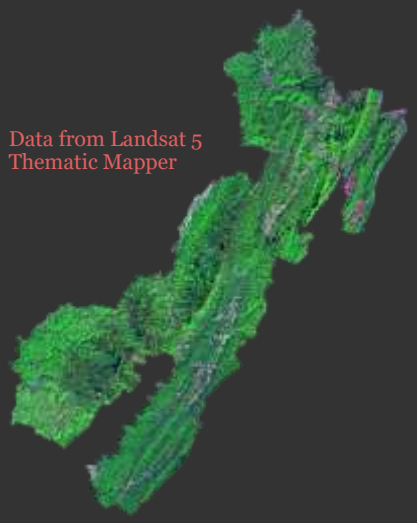
We will briefly discuss some common image data sources. However, imagery is not a major focus in this course.

Types of Imagery

- Panchromatic = Single band for entire visible spectrum (or visible and CIR)
- True Color = Red, Green, and Blue bands (RGB)
- Color Infrared = Red, Green, Blue, and Near Infrared (CIR)
- Multispectral = Multiple spectral bands collected
- Hyperspectral = Tens to hundreds of spectral bands



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Panchromatic images are black-and-white, single-band images that do not provide separate channels or bands. A wide range of wavelengths are sensed and recorded as a single gray-scale image. Although this is a bit limiting, panchromatic images are still used. In fact, panchromatic images are commonly collected along with multispectral data.

True color images are designed to mimic or simulate human vision. Your eyes contain red, green, and blue cones. Your visual system can then combine the primary colors to create a color view of the world. A true color camera works similarly. The red, green, and blue channels are collected separately and stored in separate bands. They are combined to produce a color at each pixel. Most of the images we collect on a daily basis, such as pictures taken with a cell phone, are true color images.

Color infrared, or CIR, images collect visible bands and a near infrared band. As previously discussed, near infrared wavelengths can be useful for differentiating and mapping vegetation and vegetation health. So, collecting this information can be of value. Older film-based methods were able to collect green, red, and near infrared data. Modern digital sensors can collect four bands of data: blue, green, red, and near infrared.

Multispectral images generally collect more than four bands. For example, the

Landsat 5 Thematic Mapper sensor provided one blue, one green, one red, one near infrared, two shortwave infrared, and one thermal infrared band.

Hyperspectral images can provide tens or hundreds of bands as a data cube that more closely approximates the full spectral reflectance curve at a pixel location.

Spatial Resolution

Resolution	IFOV (m)	Examples
Coarse	> 100	MODIS, AVHRR
Moderate	5 – 100	Landsat 8, Sentinel-2
Fine	< 5	IKONOS, QuickBird, WorldView-2, WorldView-3

- No agreement on exact breaks
- Often an inverse relationship between spatial resolution and temporal gain

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Sensors can be categorized based on their spatial resolution, as shown in this table. For example, moderate spatial resolution sensors have pixel sizes between 10 and 100 meters while coarse sensors have a resolution greater than 100 meters. Note that these breaks are not universally defined. You will likely see different definitions for coarse vs. moderate vs. fine spatial resolution from different sources.

No spatial resolution is better than another. Instead, it is important to use the appropriate resolution to address specific questions or needs.

Imagery Data Sources

Source	Best for	Notes
NASA Earthdata	MODIS, VIIRS, Landsat-related products, climate, atmosphere, land, ocean, cryosphere data	Important for global environmental analysis and time series.
USGS EarthExplorer / Landsat	Landsat imagery, historical satellite archive	Strong example for medium-resolution, long-term change detection.
Copernicus Data Space Ecosystem	Sentinel-1 SAR, Sentinel-2 multispectral imagery, Sentinel-3, Sentinel-5P, Copernicus products	The official Copernicus Data Space provides free access to Sentinel missions and related land, ocean, and atmosphere data. (Copernicus Data Space Ecosystem)
NOAA satellite and climate products	Weather, sea surface temperature, hurricanes, climate monitoring, coastal/ocean data	Good for meteorology, hazards, and marine/coastal GIS.
Microsoft Planetary Computer	Cloud-hosted environmental and Earth observation data in analysis-ready formats	Microsoft describes the catalog as including petabytes of environmental monitoring data in consistent, analysis-ready formats. (planetarycomputer.microsoft.com)
AWS Registry of Open Data	Cloud-hosted public datasets, including many geospatial datasets	Useful for introducing cloud-native geospatial workflows. AWS describes the registry as a way to discover and share datasets available through AWS resources. (Open Data on AWS)

This slide lists some imagery data sources and providers.

Coarse Spatial Grain Data

- Geostationary Operational Environmental Satellite (GOES) http://www.goes.noaa.gov/
- Polar Orbiting Environmental Satellite (POES) https://noaasis.noaa.gov/POLAR/poes_overview.html
- Moderate Resolution Imaging Spectrometer (MODIS) https://modis.gsfc.nasa.gov/about/specifications.php
- Visual Infrared Imaging Radiometer Suite (VIIRS) https://www.jpss.noaa.gov/viirs.html

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These are examples of coarse spatial resolution data.

Moderate Spatial Grain Data

MSS (Multispectral Scanner): Landsat 1, 2, 3, 4, and 5

Thematic Mapper (TM): Landsat 4 and 5

Enhanced Thematic Mapper Plus (ETM+): Landsat 7

Operational Land Imager (OLI)/Thermal Infrared Sensor (TIRS): Landsat 8

Operational Land Imager (OLI-2)/Thermal Infrared Sensor (TIRS-2): Landsat 9

- Multispectral Instrument (MSI): Sentinel-2

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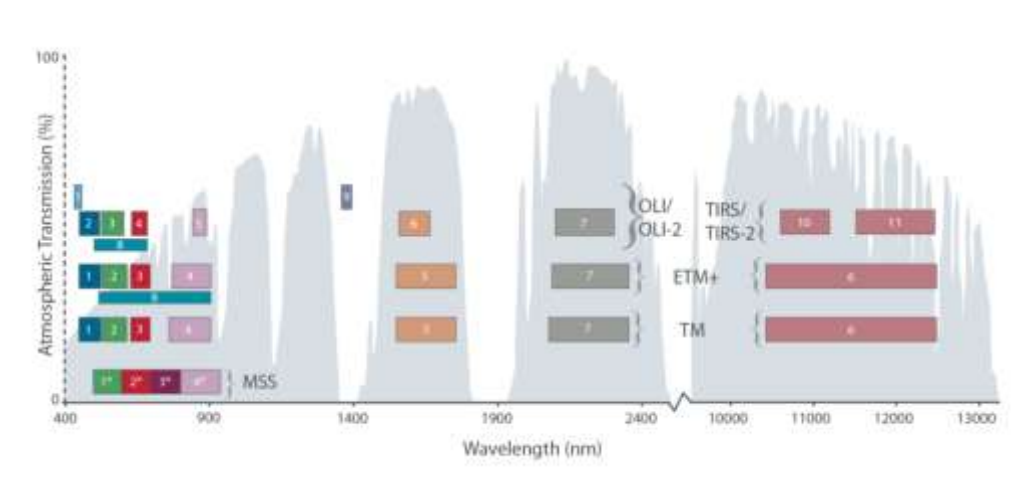
These are examples of moderate spatial resolution data.

Moderate Resolution Sensor Comparisons



https://landsat.gsfc.nasa.gov/landsat-9/landsat-9-spectral-bands/

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This NASA image provides a comparison of all the Landsat sensors. Note that not all bands of the same designation cover the same spectral ranges. For example, the NIR bands are a bit different between sensors.

Fine Spatial Grain Data

- 1999: IKONOS
- 2001: QuickBird
- 2009: WorldView-2
- 2014: WorlidView-3

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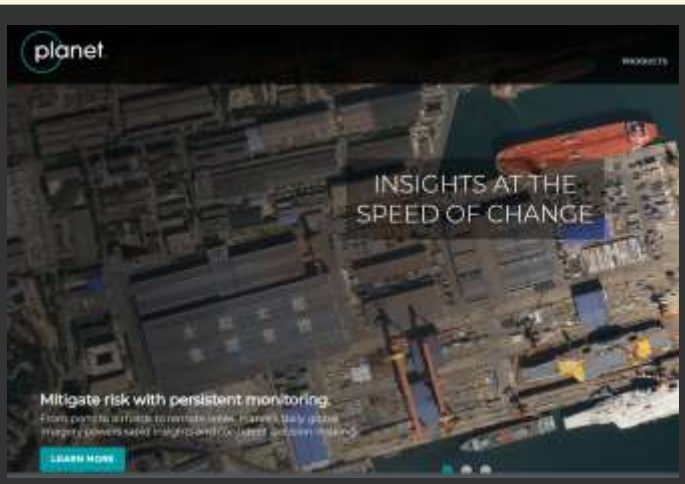
These are examples of commercial, high spatial resolution sensors with their associated launch year. Most high spatial resolution images are commercial products.

Microsatellite Constellations

- Planet Labs
- RapidEye
  - 6.5 million km² per day
- PlanetScope
  - 150+ Doves
  - 4 bands (R, G, B, NIR)
  - 3 m spatial resolution
  - 200 million km² per day
- SkySat
  - 21
  - 400 thousand km² per day
  - 5 bands (R, G, B, NIR, Panchromatic)
  - 0.8 m spatial resolution



https://www.planet.com/

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High spatial resolution and high temporal resolution are being provided by launching constellations of microsatellites. For example, Planet Labs operates PlanetScope, which, at the time of this writing, consists of over 150 doves or microsatellites. These satellites collect 4-band color infrared data at a 3-by-3 meter spatial resolution. Over 200 million square kilometers are collected per day.

They also operate SkySat, which, at the time of this writing, consists of 21 satellites that collect color infrared data and a panchromatic band. Over four-hundred thousand square kilometers are collected each day.

Such projects are revolutionizing remote sensing and Earth observation.

Finding Free Imagery

- USGS EarthExplorer
- http://earthexplorer.usgs.gov/

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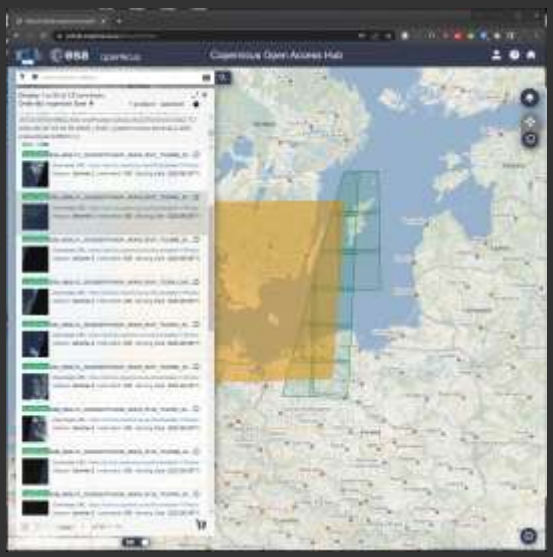
The USGS EarthExplorer page provides free access to a variety of datasets including Landsat, AVHRR, MODIS, and aerial imagery.

Finding Free Imagery



- ESA Copernicus
- https://cds.climate.copernicus.eu/#!/home
- https://scihub.copernicus.eu/

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The European Space Agency (ESA) also has data portals available to download satellite data, such as imagery from the Sentinel-2 and Sentinel-3 sensors.

Buying Imagery

https://www.maxar.com/

https://www.satimagingcorp.com/

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You can also purchase imagery from a commercial provider or third-party company.

Data can be purchased from an existing data archive. Additionally, sometimes it is possible to have a satellite tasked. In this case, the satellite can be pointed at a specific target or area on a specific date to collect custom data.

Elevation

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We will now discuss sources of elevation data.

What are the sources of terrain data

1. Contour Lines and hypsography data
2. Photogrammetry
3. Radar (Radio Detection and Ranging)
4. LiDAR (Light Detection and Ranging)
5. GPS
6. Structure from Motion

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There are many methods available to create digital terrain data. Since this is not a remote sensing class, I will not cover these methods in detail. Instead, I will provide just a brief introduction.

Radio Detection and Ranging (RaDAR)

- SRTM (Shuttle Radar Topography Mission)
- February 2000
- 11 day mission
- Mapped 80% of world at 90 m resolution
- 30 meter over US

https://www2.jpl.nasa.gov/srtm/

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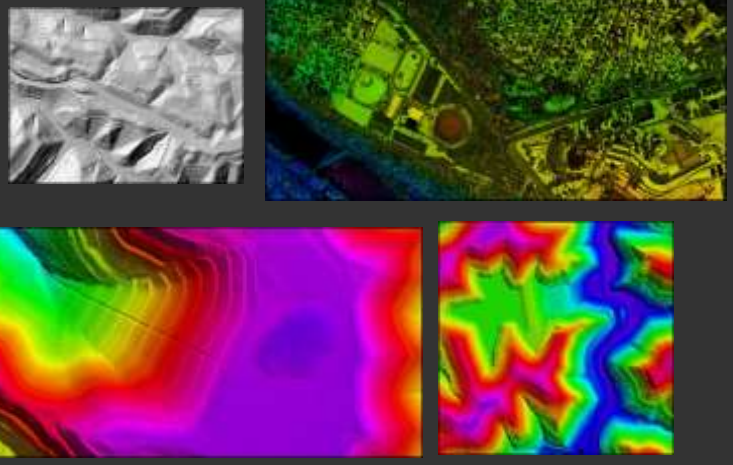
RaDAR, or radio detection and ranging, uses radio waves or microwaves to map terrain surfaces. An active sensor releases radio waves or microwaves. The waves can then strike a target then potentially bounce back to a detector. The system can then record the two-way travel time and use this information to determine the distance between the sensor and surface. If the location of the sensor is known, then elevations can be derived.

One example of RaDAR data is the Shuttle Radar Topography Mission, or SRTM, data. These data were collected in February of 2000 during an 11-day mission in which 80% of the globe was mapped. 90 m spatial resolution data are available globally and 30 m data are available over the United States. Later, the 90 m data were made available at 30 m.

Light Detection and Ranging (LiDAR)

- Use laser pulses
- Often collected from a aircraft
- Provides multiple returns per each laser pulse
- High resolution (sub meters)
- High accuracy (+/- 10 cm)



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Light detection and ranging, or LiDAR, is similar to RaDAR in that the two-way travel time of electromagnetic radiation is used. However, shorter wavelengths are used, generally a visible or near infrared wavelength. LiDAR generally allows for the collection of very accurate and precise elevation data at a high spatial resolution. It is possible to generate sub-meter elevation data with accuracies in the centimeter range. These data can be collected from aircrafts, satellites, and drones.

Structure from Motion (SfM)

- Terrain data created from overlapping drone imagery

Image provided by NRAC

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Digital surface models can be generated from overlapping drone images using the structure from motion, or SfM, methodology. Structure from motion is similar to photogrammetric methods as it makes use of overlapping stereo images and stereo parallax. Currently, it is not easy to generate DTM or DEM models, or remove above ground features.

USGS 3DEP Program

- Free elevation data download
- Draws from a variety of data sources
- A replacement for the National Elevation Dataset (NED)
- This is still developing

https://nationalmap.gov/3DEP/

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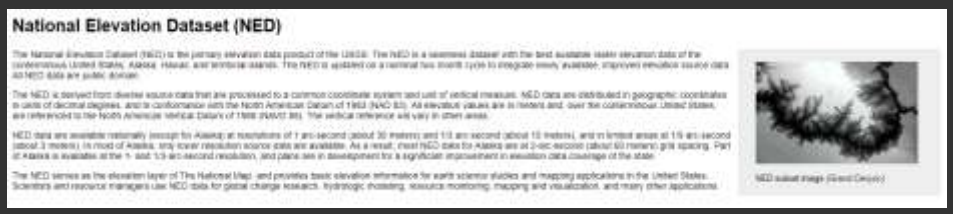
The 3DEP program in the United States is working toward high resolution, predominantly LiDAR-derived, elevation data for the entire country. Interferometric Synthetic Aperture RaDAR, or IfSAR, data will be collected over Alaska.

This program is ongoing. A nationwide LiDAR coverage is not currently available, but should be available soon.

National Elevation Dataset (NED)

- US data
- 30 m (1 arc-second)
- 10 m (1/3 arc-second)
- 3 m (1/9 arc-second)

http://wvgis.wvu.edu/data/dataset.php?ID=28



https://lta.cr.usgs.gov/NED

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3DEP replaced the older National Elevation Dataset, or NED, program. This program provides digital elevation data at variable spatial resolutions for the United States. Depending on your location, 30 meter, 10 meter, or 3 meter data may be available. These data were generated using primarily stereo imagery and photogrammetric methods. These data are now being replaced with LiDAR-derived versions, essentially coarsening the 1 m DEMs being generated using LiDAR.

WV Statewide Addressing and Mapping Board (WVSAMB) 3 m Data

- Photogrammetric DEM
- 2003
- 3 m data

http://wvgis.wvu.edu/data/dataset.php?ID=261

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In West Virginia, 3 meter digital elevation data were generated using stereo imagery and photogrammetric methods.

These data are made available from the West Virginia Statewide Addressing and Mapping Board (WVSAMB) and can be downloaded from the West Virginia GIS Tech Center.

ASTER Global Digital Elevation

- Photogrammetric
- Derived from the Advanced Spaceborne Thermal Emission Reflectance Radiometer (ASTER) onboard Terra
- Global coverage
- 30 m

https://asterweb.jpl.nasa.gov/gdem.asp

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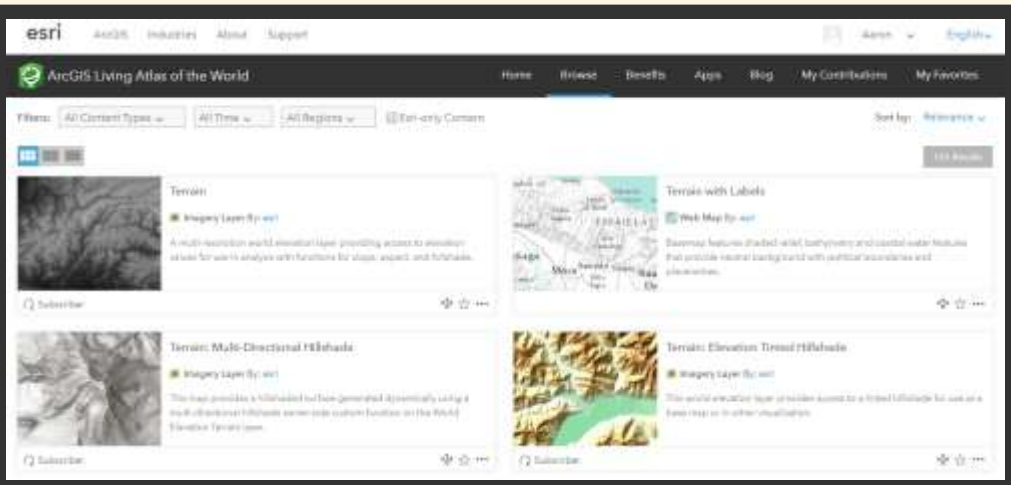
Another example of digital elevation data is the ASTER Global Elevation Map. These data were generated from the ASTER sensor onboard the Terra satellite. ASTER stands for Advanced Spaceborne Thermal Emission Reflectance Radiometer. These data were generated using stereo imagery and photogrammetric methods and offer a global coverage at 30 meter spatial resolution.

DEM data from Living Atlas



https://livingatlas.arcgis.com/en/home/

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Digital elevation data and derived products are also made available by ESRI via the Living Atlas of the World.

Data Services

ESRI Open Data

http://www.esri.com/software/open/open-data

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ESRI provides access to a wide variety of free and open data layers through their Open Data website.

ArcGIS Living Atlas of the World

https://livingatlas.arcgis.com/en/

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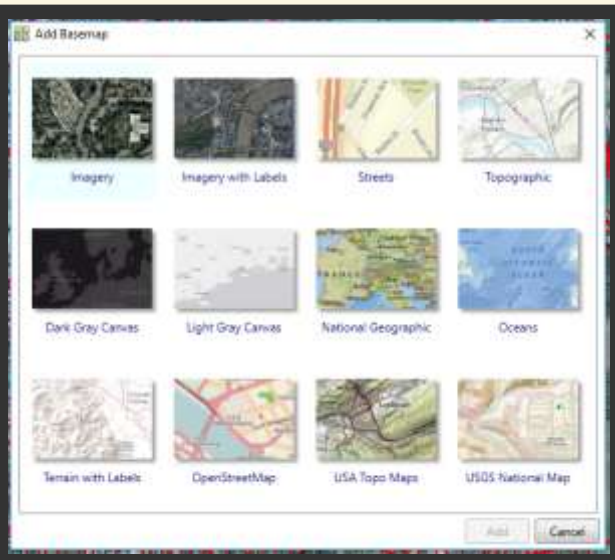
With a valid ArcGIS Online account, you can also access data via the ArcGIS Living Atlas of the World. These data layers can be used in both ArcGIS Pro and ArcGIS Online. Analyses can even be performed on some of the layers.

ArcGIS Basemaps



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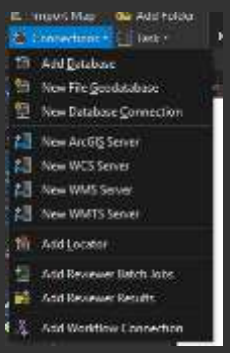
ESRI also provides a variety of basemaps that can be used in ArcGIS Pro and ArcGIS Online.

Connecting to Servers in ArcGIS Pro



https://www.mapwv.gov/gis_services.html

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It is not always necessary to download data. For example, you can connect to GIS web services to stream web data into a web map or ArcGIS Pro.

Open-Source Data

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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.