

Introduction to Spatial Data

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Key concepts, data types, sources, and basic workflows

1. What Is Spatial Data?

Term	Definition
Spatial data (or geospatial data)	Information that describes the location, shape, and relationship of objects on Earth (or any coordinate-based space).
Attribute data	Non-spatial information linked to a spatial feature (e.g., population of a city, land-use type).
Coordinate reference system (CRS)	The mathematical framework that translates real-world positions into numeric coordinates (e.g., latitude/longitude, UTM).

Why it matters: Enables mapping, analysis of patterns, routing, environmental modeling, urban planning, disaster response, etc.

2. Core Data Models

Model	Geometry Type(s)	Typical Use	Storage Format
Vector	Points, lines, polygons (and multi-geometries)	Discrete features – cities, roads, parcels	Shapefile, GeoJSON, GPKG, KML, File Geodatabase
Raster	Grid of cells (pixels) with a value per cell	Continuous phenomena – elevation, temperature, satellite imagery	GeoTIFF, IMG, NetCDF, HDF
TIN (Triangulated Irregular Network)	Irregular triangles	Surface modeling where data are unevenly spaced (e.g., LiDAR)	.tin, GPKG (vector)
Network	Nodes + edges with connectivity rules	Transportation, utility networks	ESRI Network Dataset, pgRouting tables

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3. Common Spatial Data Formats

Category	Format	Strengths	Limitations
Vector	Shapefile (.shp)	Widely supported, simple	1?GB size limit, limited attribute length, separate files
	GeoJSON (.geojson)	Web?friendly, human?readable	Larger file size than binary equivalents
	GeoPackage (.gpkg)	Single?file, supports raster & vector, SQLite?based	Newer; some legacy tools lack full support
Raster	GeoTIFF (.tif)	Embedded CRS, lossless compression options	Large files for high?resolution data
	NetCDF (.nc)	Multidimensional scientific data, metadata rich	Complex; requires specialized libraries
Imagery	JPEG2000, ECW	High compression ratios	Proprietary licensing (ECW)
Web Services	WMS, WMTS, WFS, WCS	On?demand data delivery, standards?based	Dependent on internet connectivity and server performance

4. Sources of Spatial Data

Source	Description	Typical Access Method
Government agencies (e.g., USGS, INSPIRE, NGA)	Topographic maps, cadastral parcels, elevation models	Download portals, APIs
Open data portals (OpenStreetMap, Natural Earth)	Crowd?sourced or curated global datasets	OSM API, vector tiles, bulk extracts
Commercial providers (e.g., DigitalGlobe, HERE)	High?resolution satellite imagery, traffic data	Subscription, cloud storage
Sensor networks (LiDAR, UAV, IoT)	Point clouds, real?time environmental readings	Direct file transfer, streaming APIs
Scientific repositories (Copernicus, NASA)	Climate, ocean, atmospheric data	FTP, O