Introduction to Data Models

Chapter 2, GIS Fundamentals, Bolstad & Manson

Introduce the concept of data models

Introduce Cartesian and Spherical Coordinate Systems

Highlight peculiarities of spherical coordinates, distance, shape

Data Models

We approximate important parts of the **real world** with **data models**, organized in **data structures**

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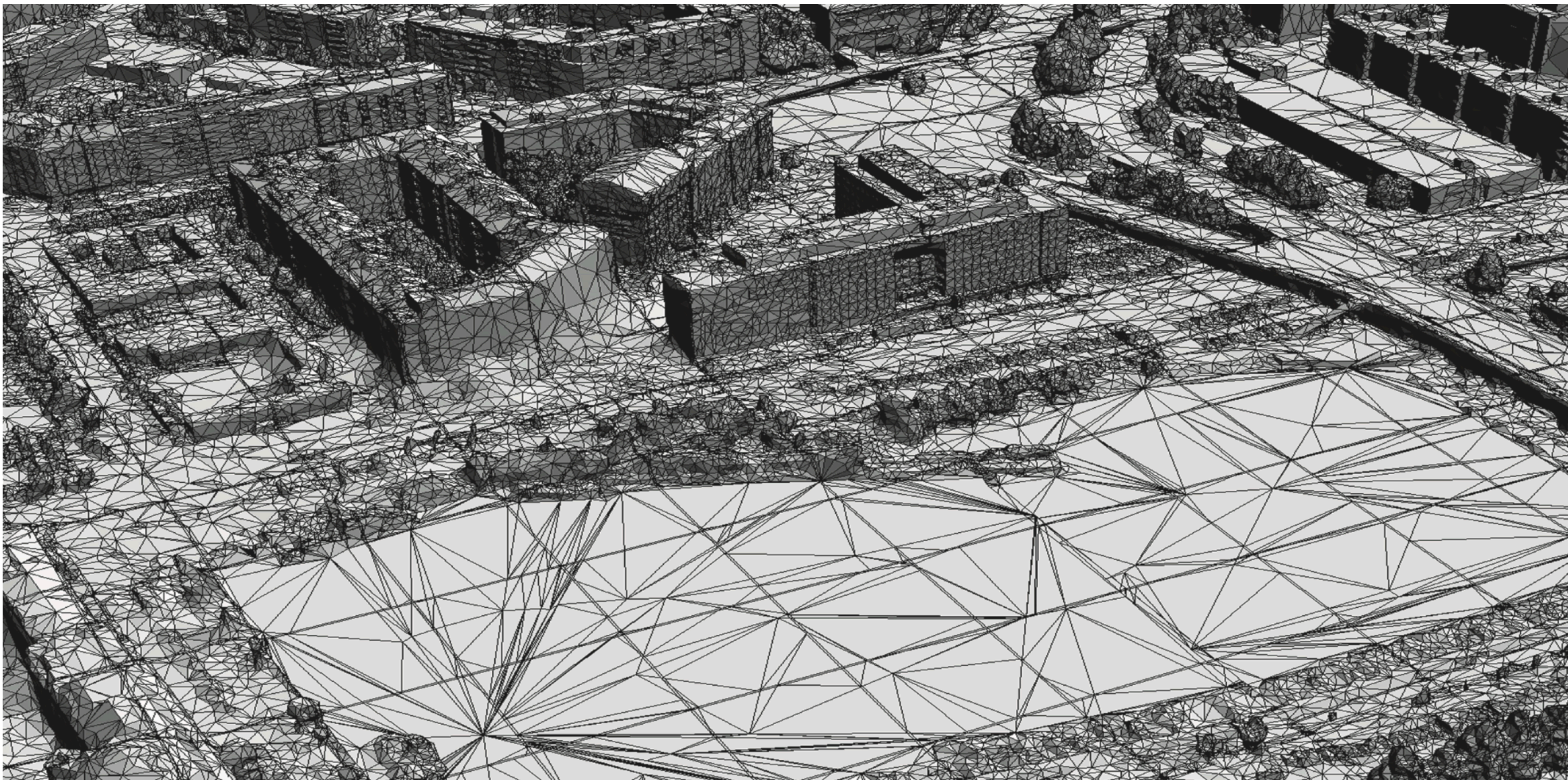


Real world

phenomena that exist

Data model

ID	Area	Type
1	16.3	PUB
2	7.9	PEM
3	121.8	U
4	10.1	PUB
...	...	...

An abstraction, relevant phenomena and properties

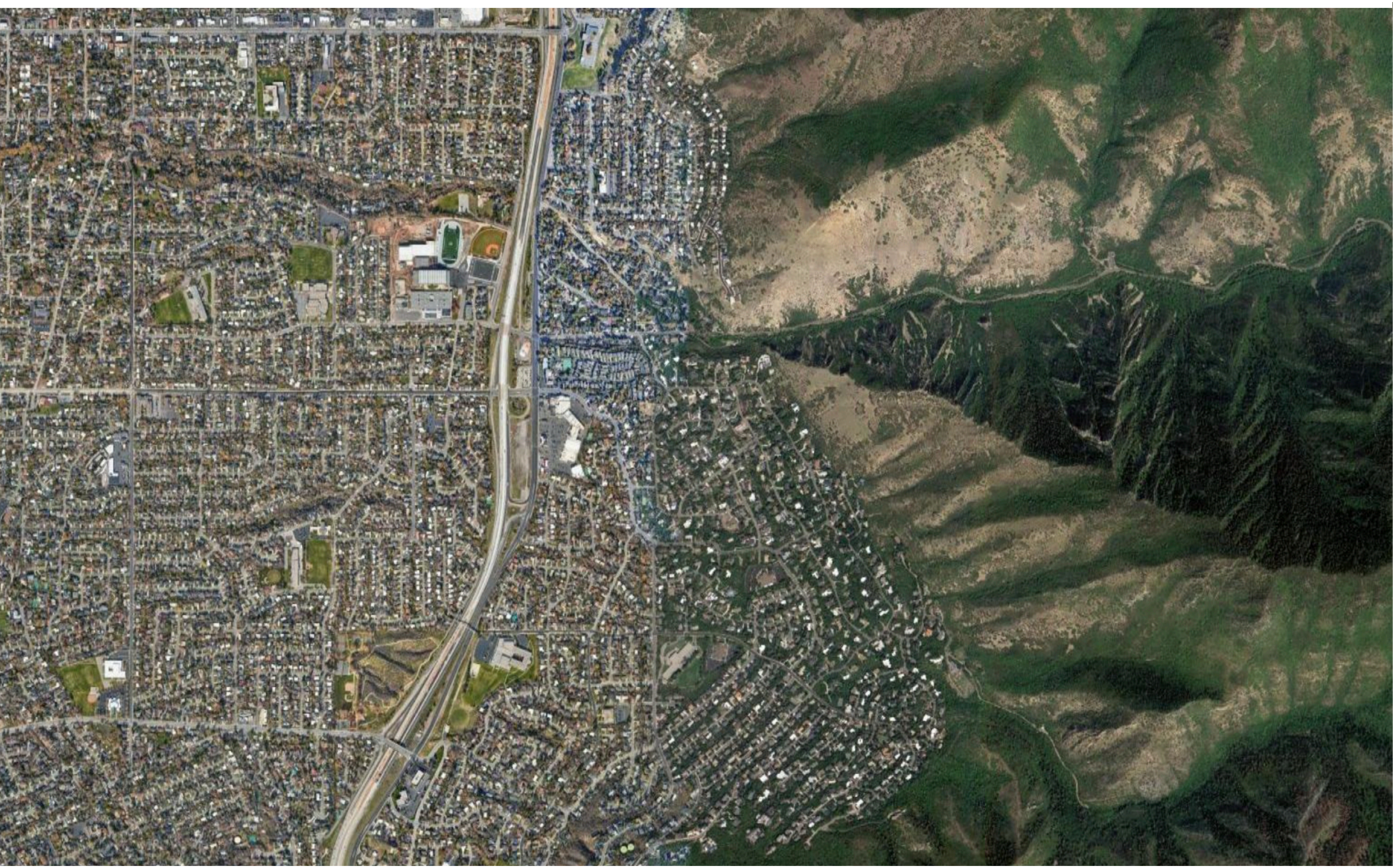
Data structure

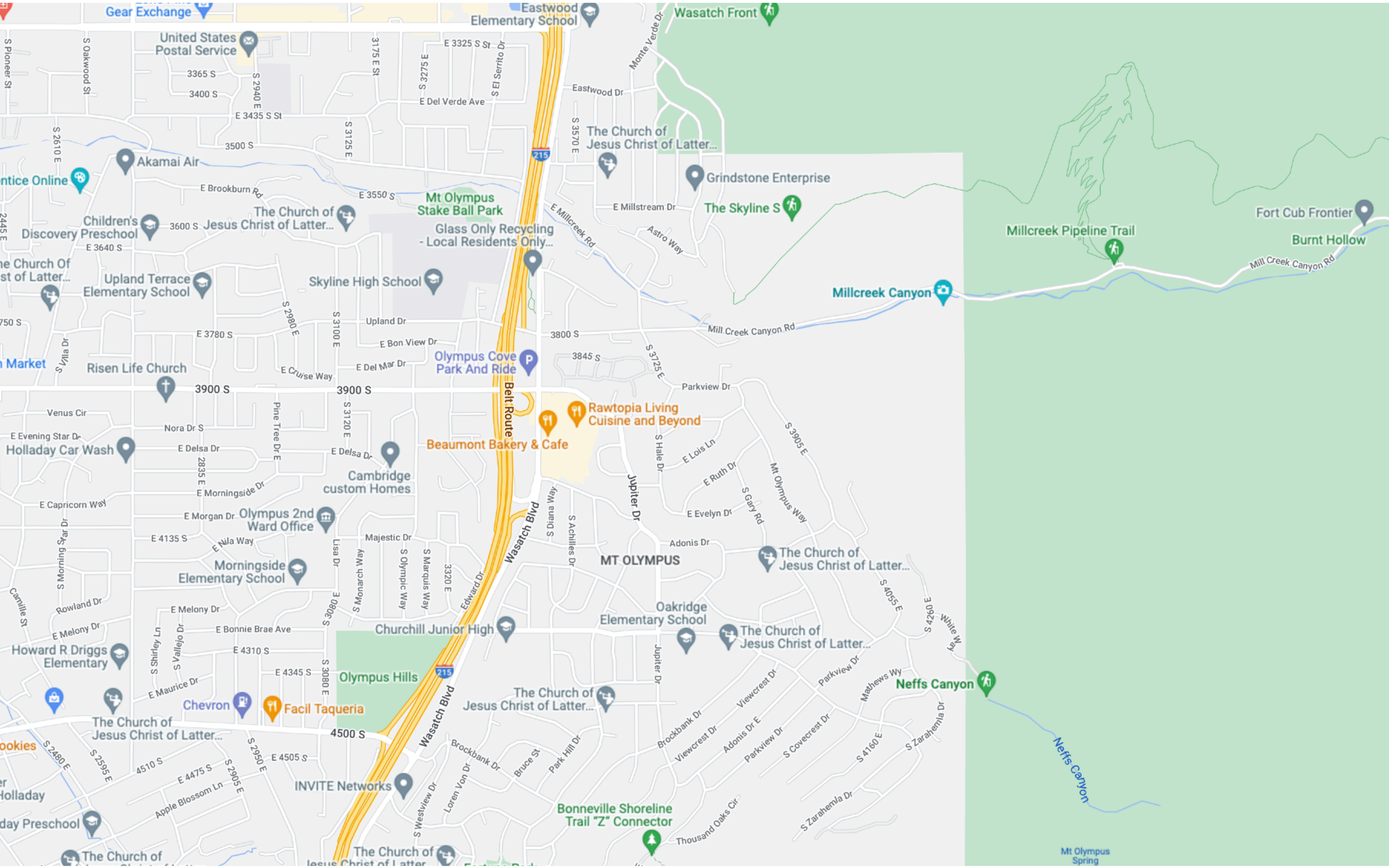
x	y
1.2	4.7
5.8	3.6
8.9	7.2
.	
.	

Machine code

computer representation

10011101
00110110
10110100




Gear Exchange
Eastwood Elementary School
Wasatch Front
United States Postal Service
E 3325 S St
3365 S
3400 S
E 3435 S St
E Del Verde Ave
Eastwood Dr
Monte Verde Dr
3500 S
The Church of Jesus Christ of Latter...
Akamai Air
Grindstone Enterprise
E Brookburn Rd
E 3550 S
Mt Olympus Stake Ball Park
E Millstream Dr
The Skyline S
Fort Cub Frontier
Children's Discovery Preschool
3600 S
Jesus Christ of Latter...
Glass Only Recycling - Local Residents Only...
E Millcreek Rd
Astro Way
Millcreek Pipeline Trail
Burnt Hollow
E 3640 S
Mill Creek Canyon Rd
Upland Terrace Elementary School
Skyline High School
Millcreek Canyon
Upland Dr
E 3780 S
E Bon View Dr
3800 S
Olympus Cove Park And Ride
3845 S
Risen Life Church
E Cruise Way
E Del Mar Dr
Parkview Dr
3900 S
Belt Route
Venus Cir
Rawtopia Living Cuisine and Beyond
Nora Dr S
E Evening Star Dr
Holladay Car Wash
E Delsa Dr
Beaumont Bakery & Cafe
E Lois Ln
E Ruth Dr
Cambridge custom Homes
Jupiter Dr
E Morningside Dr
E Capricorn Way
E Morgan Dr
Olympus 2nd Ward Office
E Evelyn Dr
Mt Olympus Way
E 4135 S
E Nila Way
Majestic Dr
Wasatch Blvd
Adonis Dr
MT OLYMPUS
Morningside Elementary School
The Church of Jesus Christ of Latter...
Rowland Dr
E Melony Dr
Oakridge Elementary School
E Bonnie Brae Ave
Churchill Junior High
The Church of Jesus Christ of Latter...
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Mt Olympus Spring
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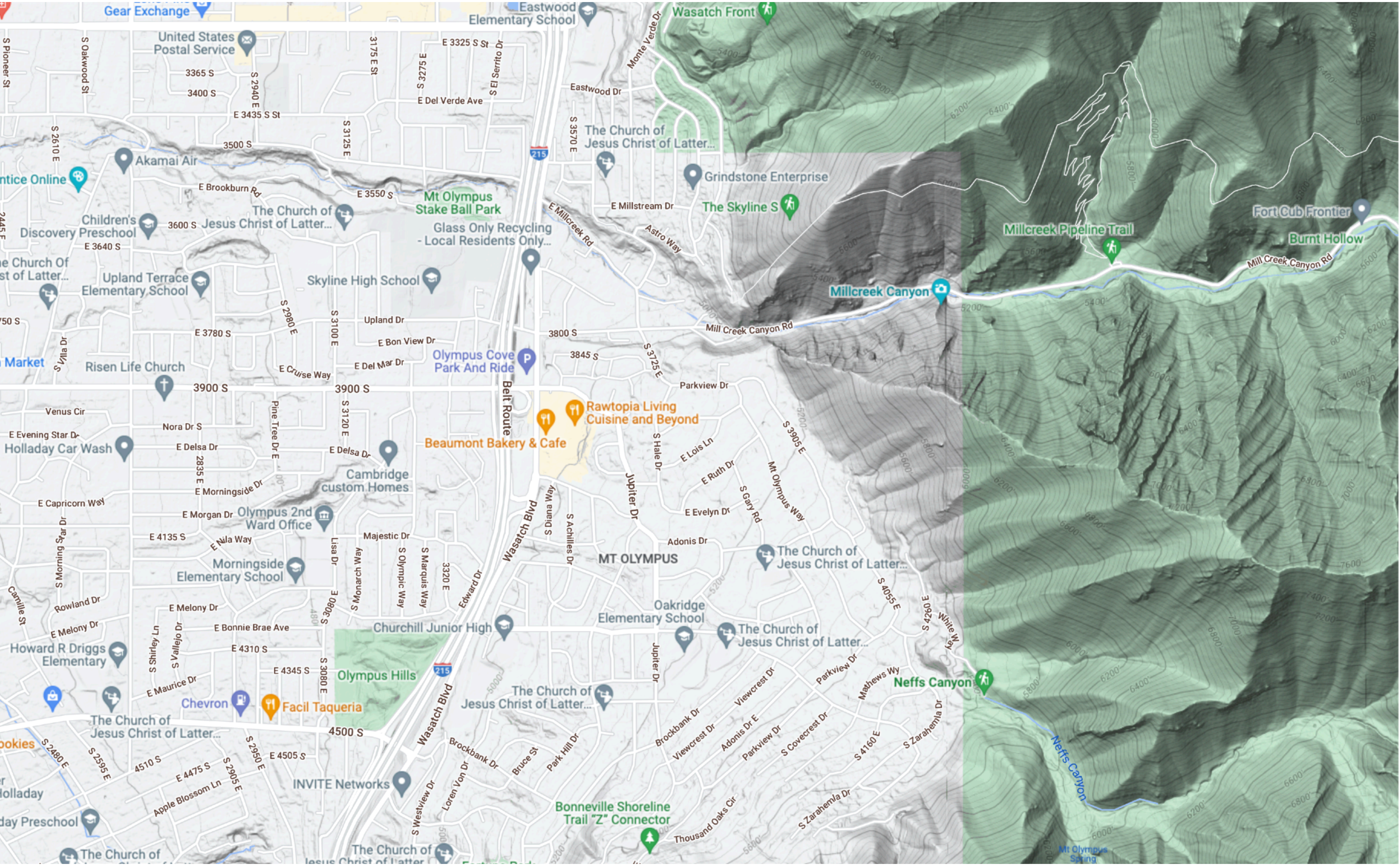
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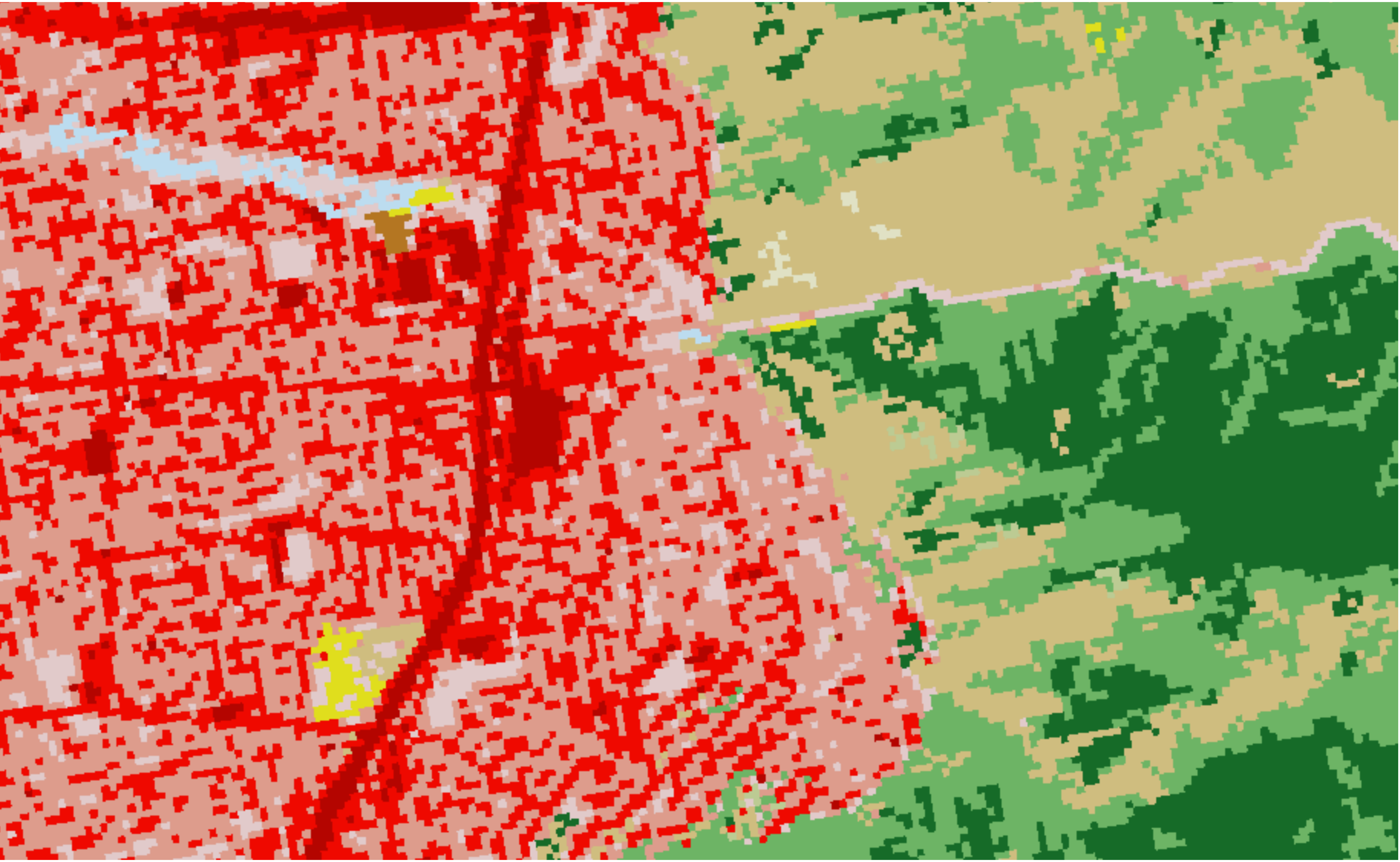
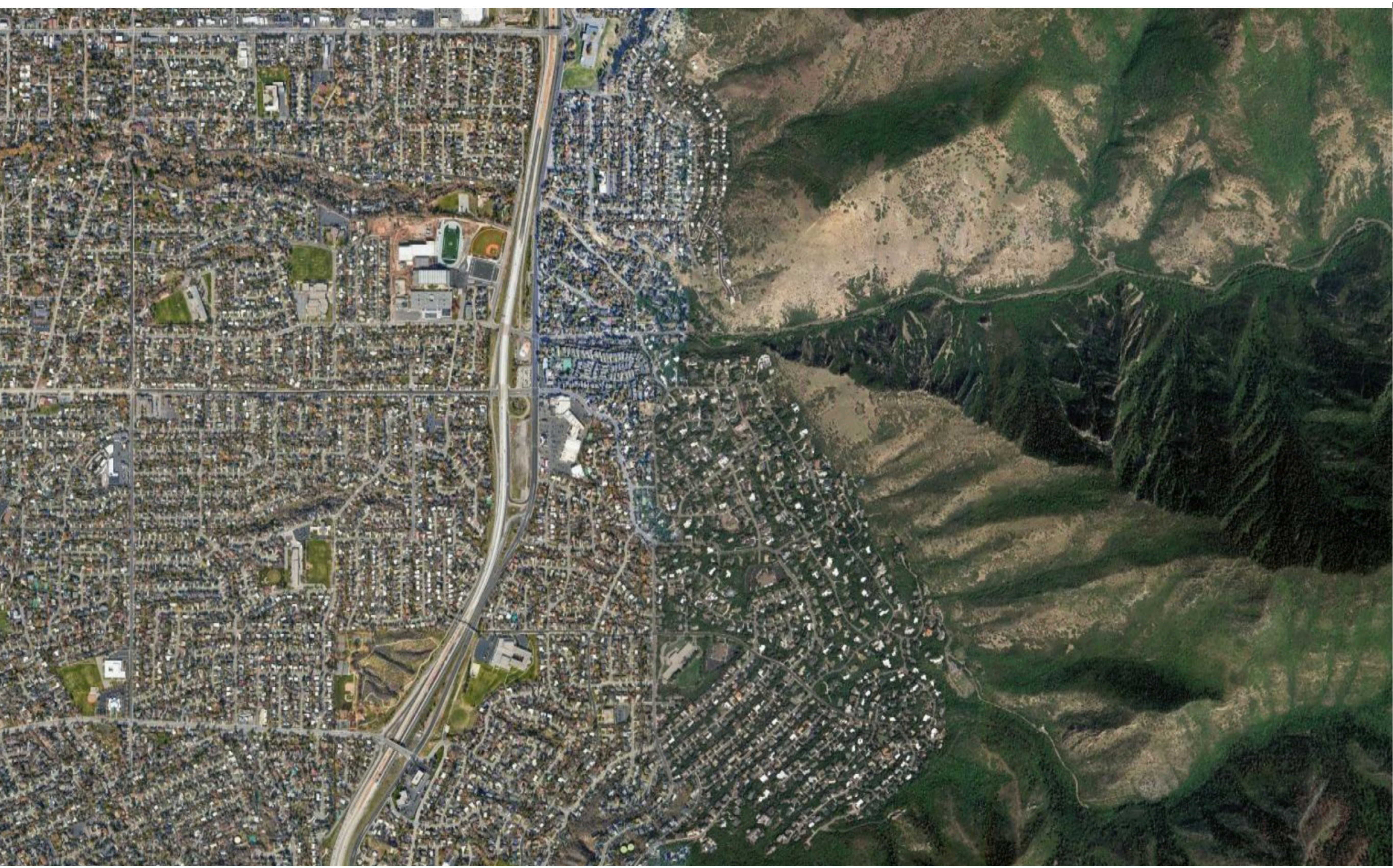
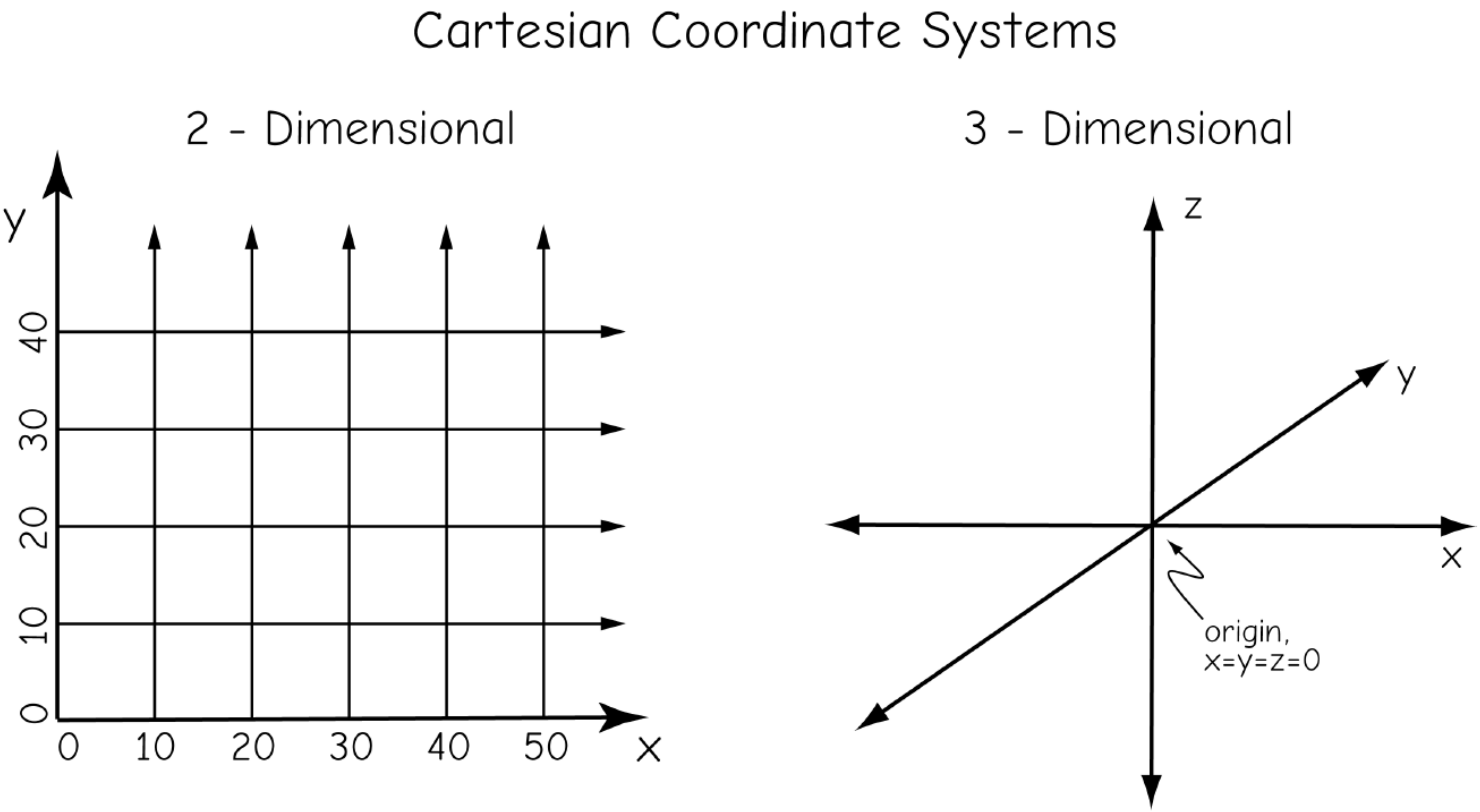
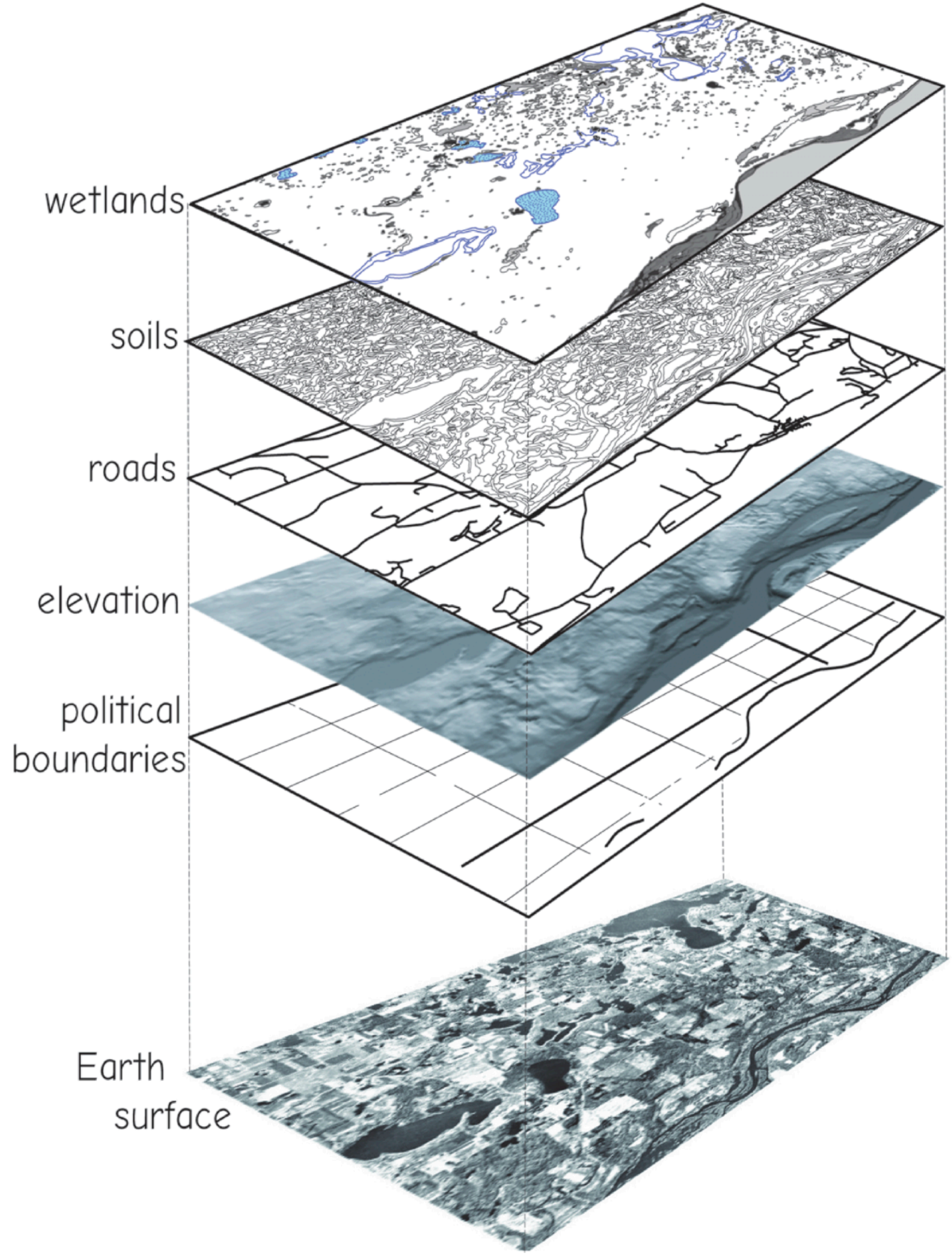


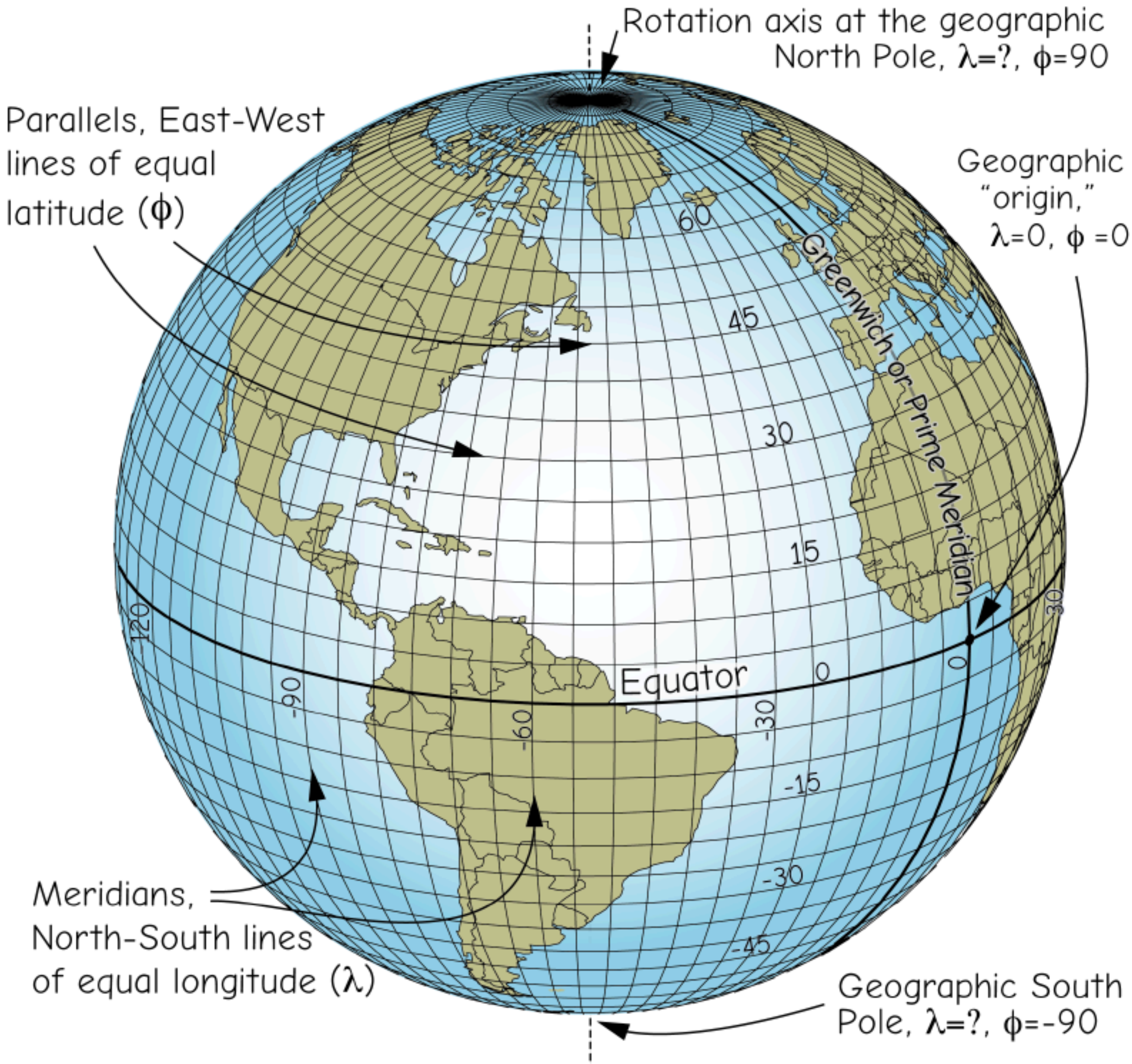


Coordinates - the Geographic in GIS



Data as Thematic Layers



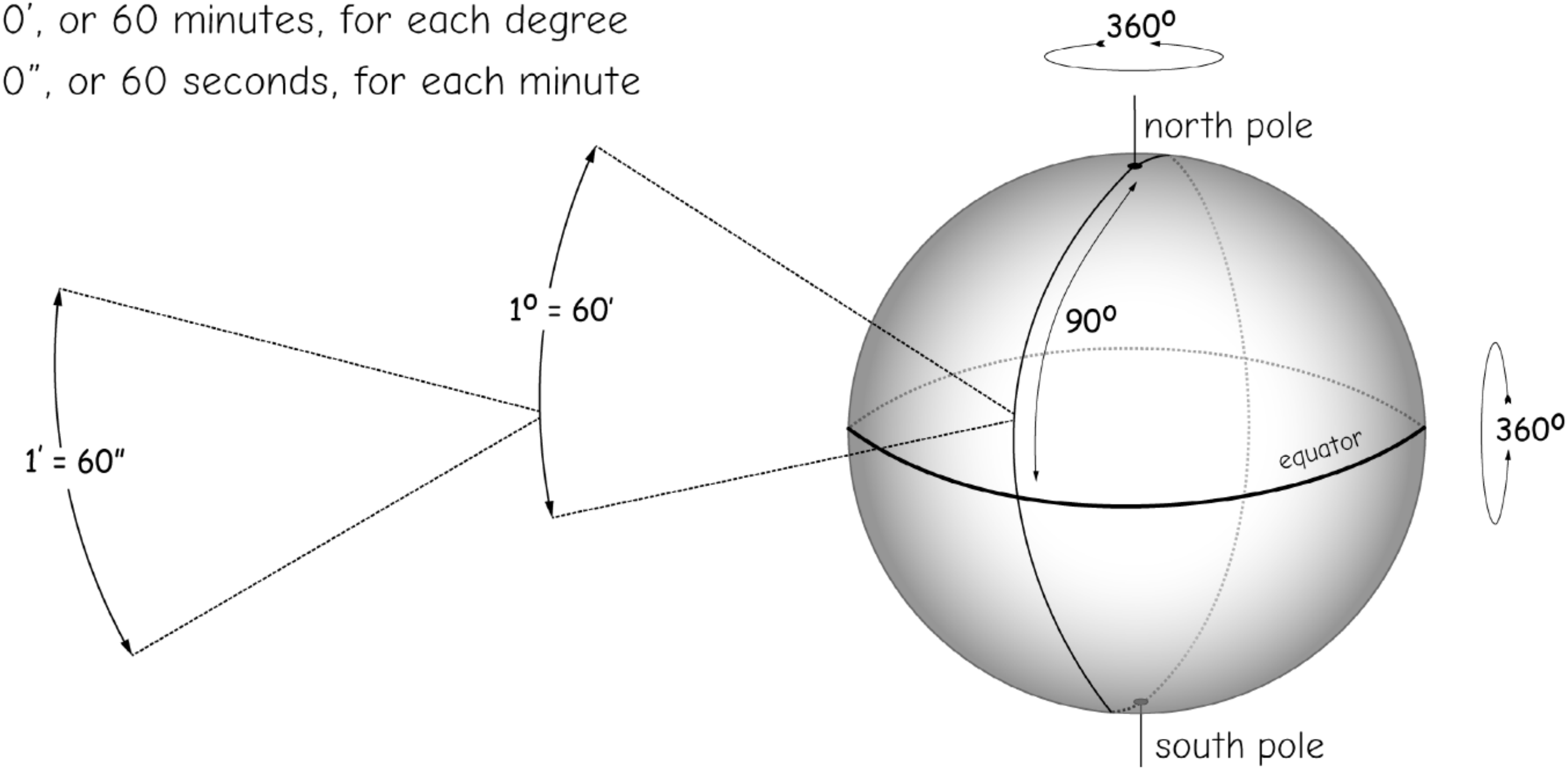

Rotation axis at the geographic North Pole, λ=?, φ=90
Parallels, East-West lines of equal latitude (φ)
Geographic "origin," λ=0, φ=0
Greenwich or Prime Meridian
60
45
30
15
0
-15
-30
-45
Equator
120
-90
-60
-30
0
30
Meridians, North-South lines of equal longitude (λ)
Geographic South Pole, λ=?, φ=-90

Spherical Coordinates - Lat/long

360^o to circle the sphere

60', or 60 minutes, for each degree

60", or 60 seconds, for each minute

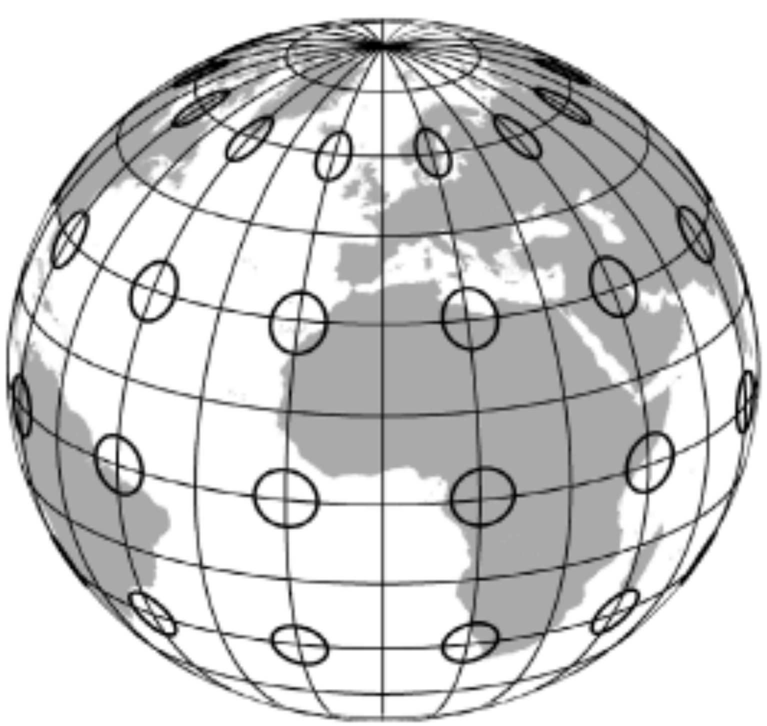


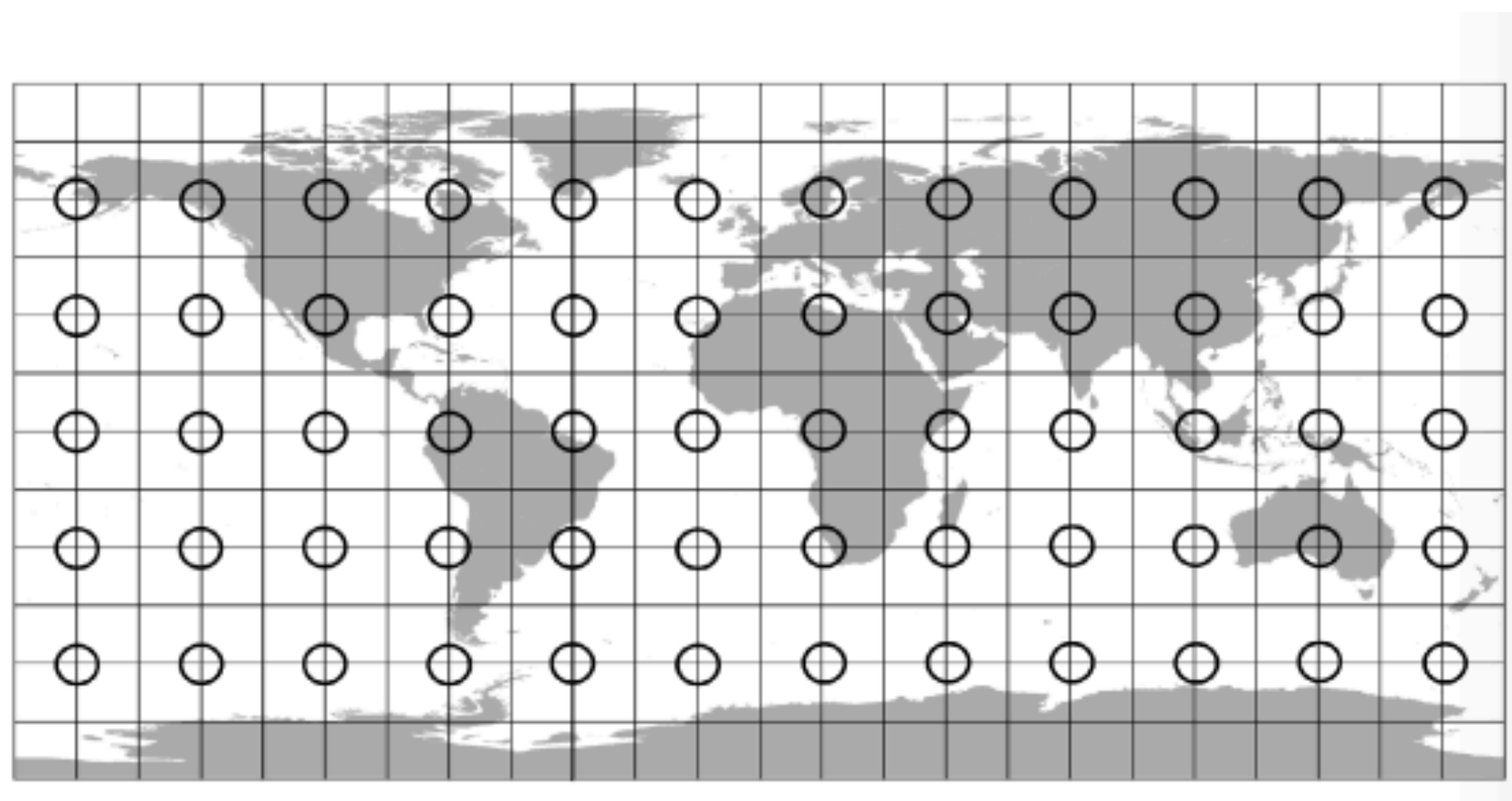
Geographic Coordinates are Inherently Distorted

Meridians Converge at the Poles

The distance spanned by a degree in the latitude (x) direction is different near the Equator than near the Poles

This distorts distance, shape, and direction in a Cartesian plot

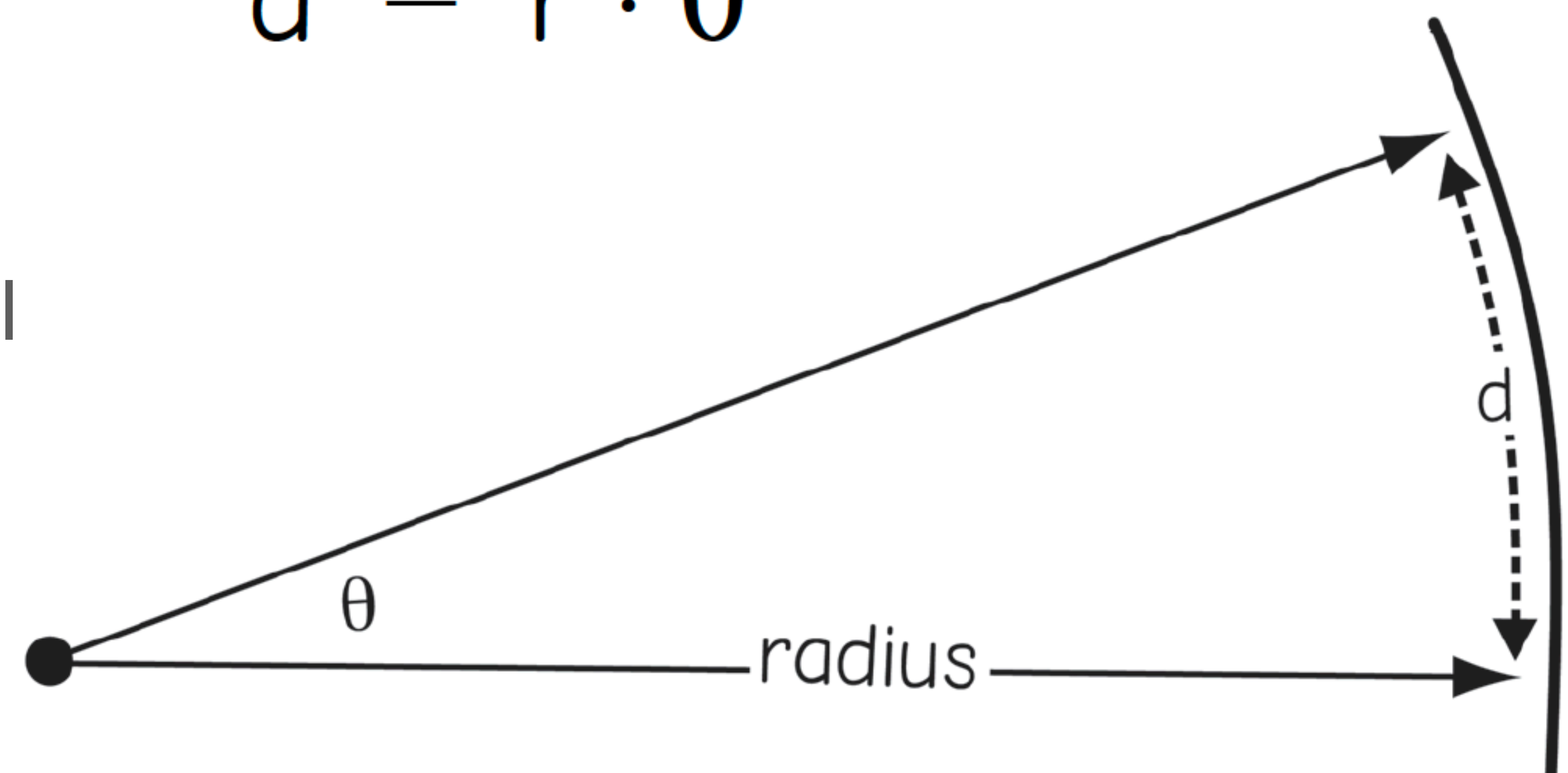




Surface Distances on a Sphere (first approximation)

$$d = r \cdot \theta$$

- It's an approximation
- Theta is the non-directional angle, and will usually not equal the difference in latitudes/longitudes
- Theta is measured in radians



$$d = \text{radius} \bullet \theta$$

where θ is measured in radians,
with
1 radian = 57.2957°

True Distances on A Globe a Bit More Complicated

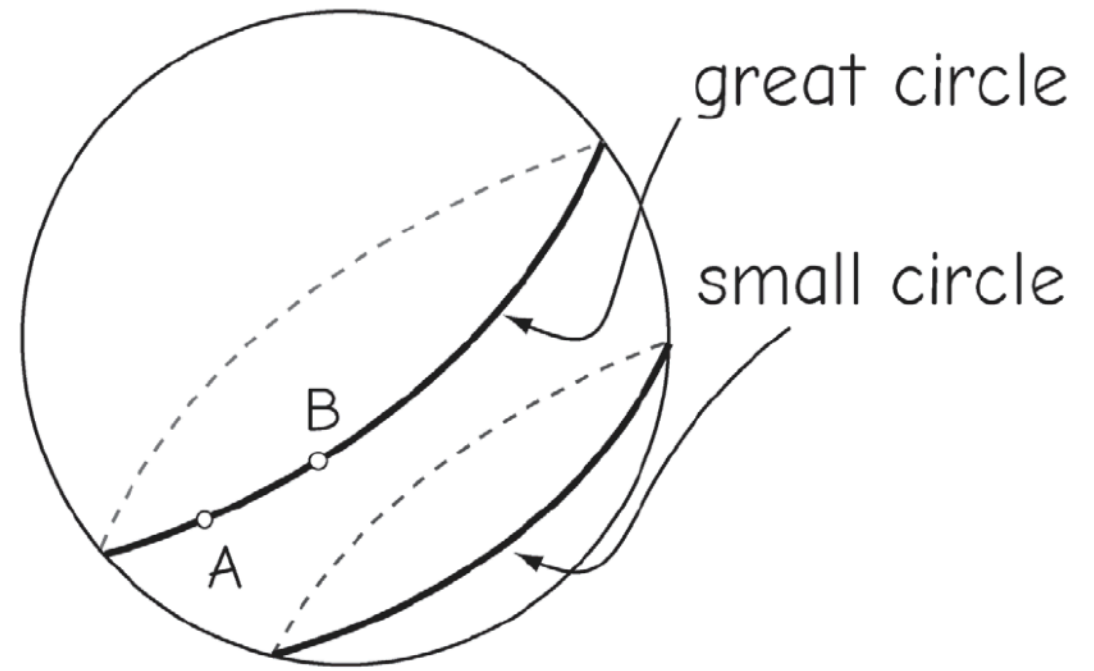
Great Circle Distance

Spherical approximation

Consider two points on the Earth's surface,

A with latitude, longitude of (ϕ_A, λ_A), and

B with latitude, longitude of (ϕ_B, λ_B)



The great circle distance between points on a sphere is given by the formula:

$$d = r \cdot 2 \ \sin^{-1}\sqrt{[(\sin^2(\frac{\Delta\phi}{2})) + \cos(\phi_A) \cdot \cos(\phi_B) \cdot \sin^2(\frac{\Delta\lambda}{2})]}$$

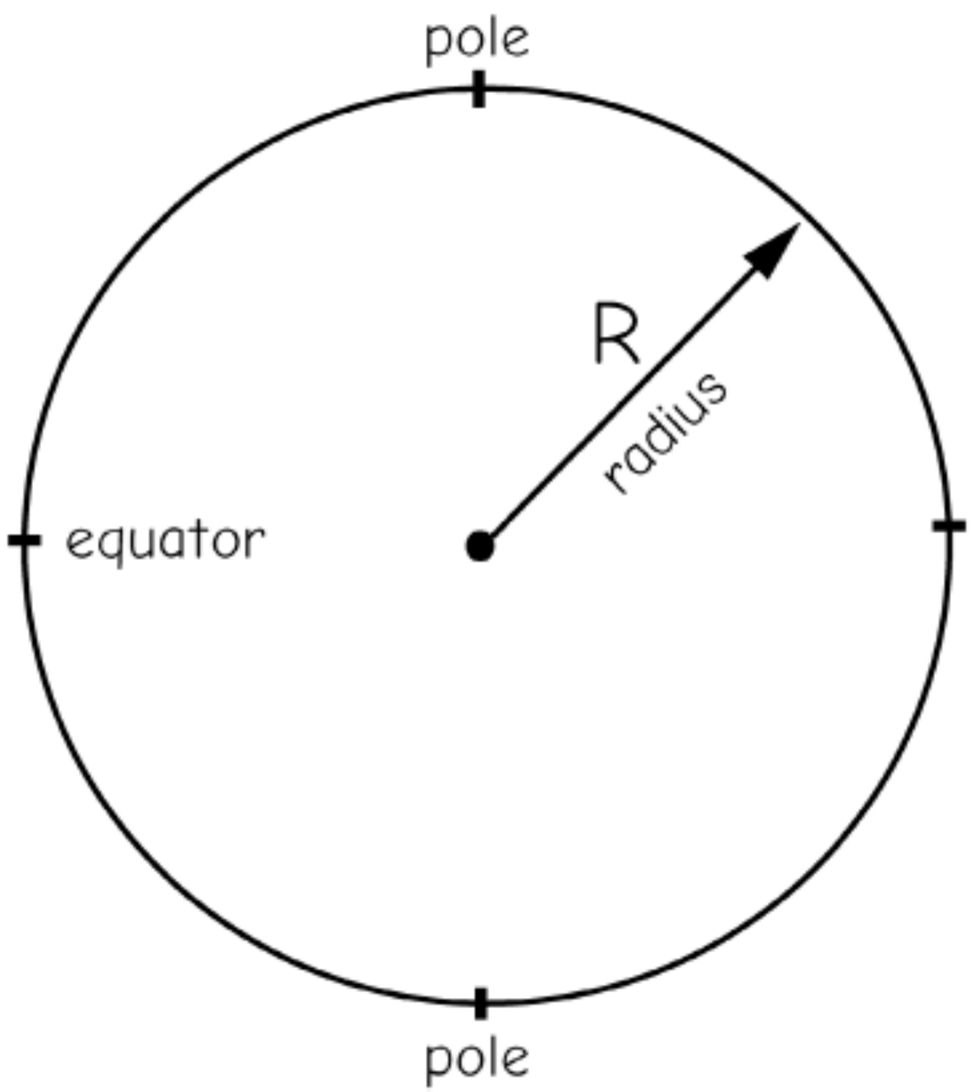
Great Circle Distances often appear curved on Cartesian plots, despite being the shortest distance between points

It’s Even More Complicated - An Ellipsoid is a Better Approximation of the Earth’s Shape

Mathematical Definition of Our Earth

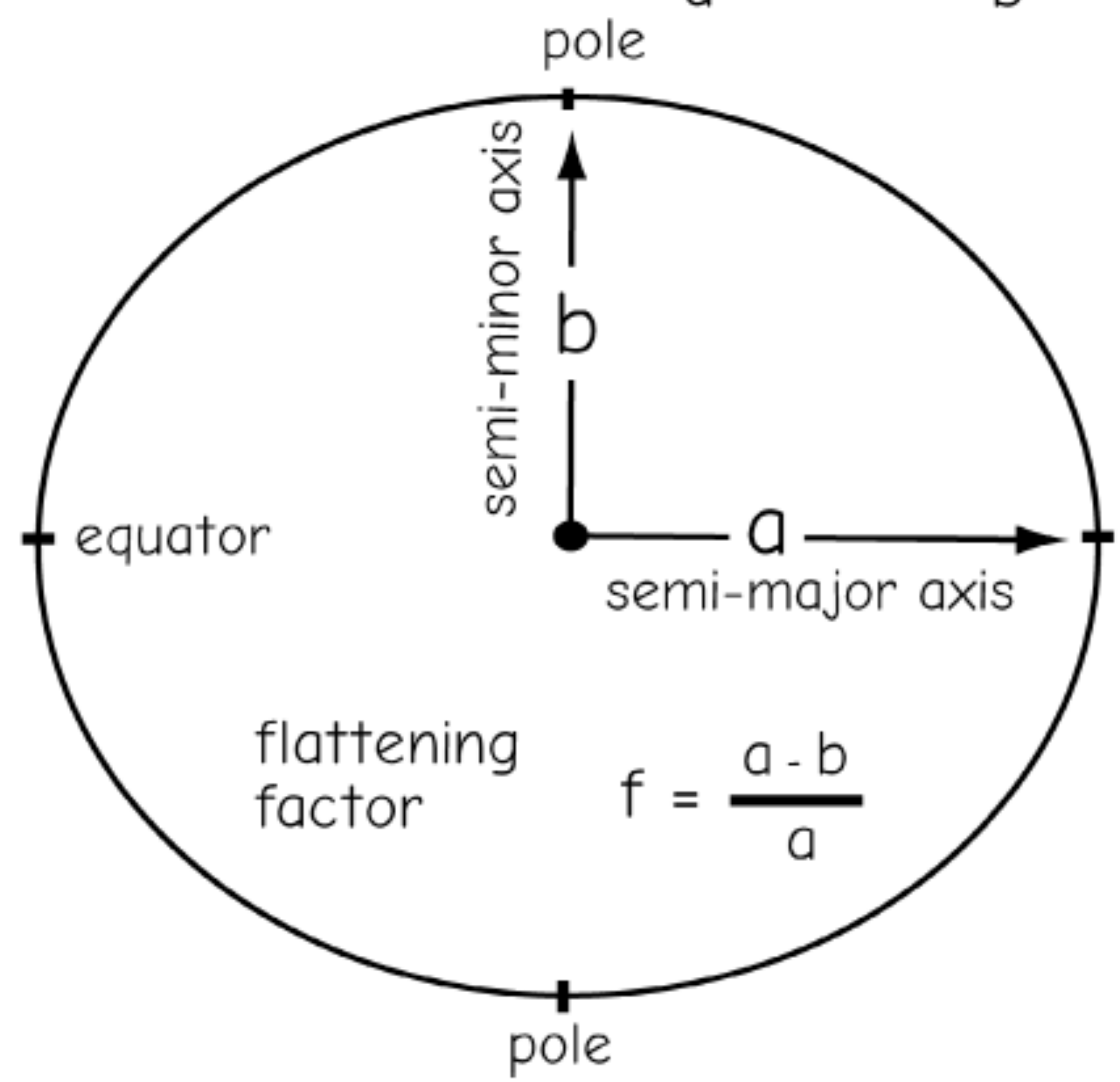
Sphere

$$R^2 = (x-x_o)^2 + (y-y_o)^2$$

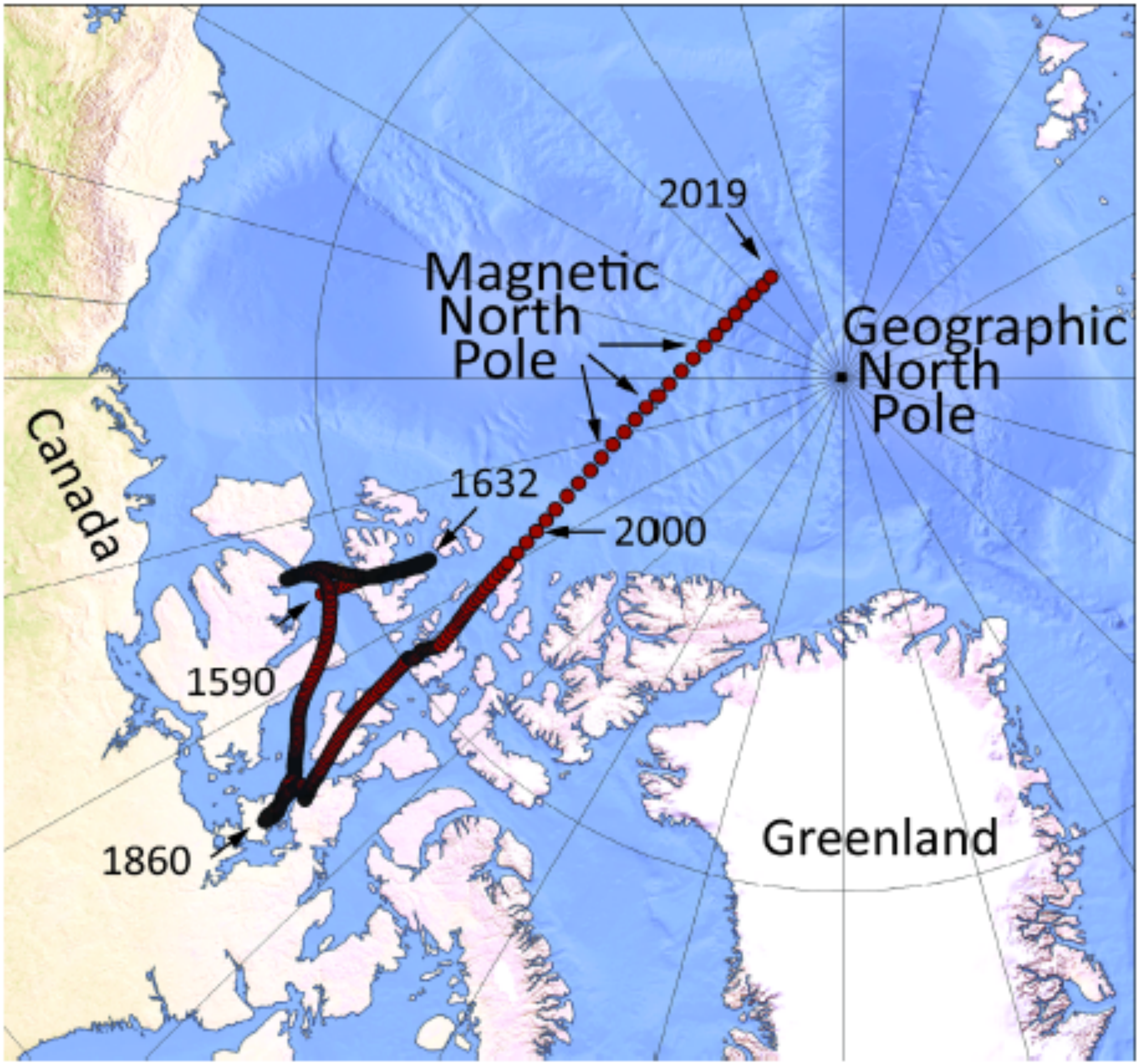


Ellipse

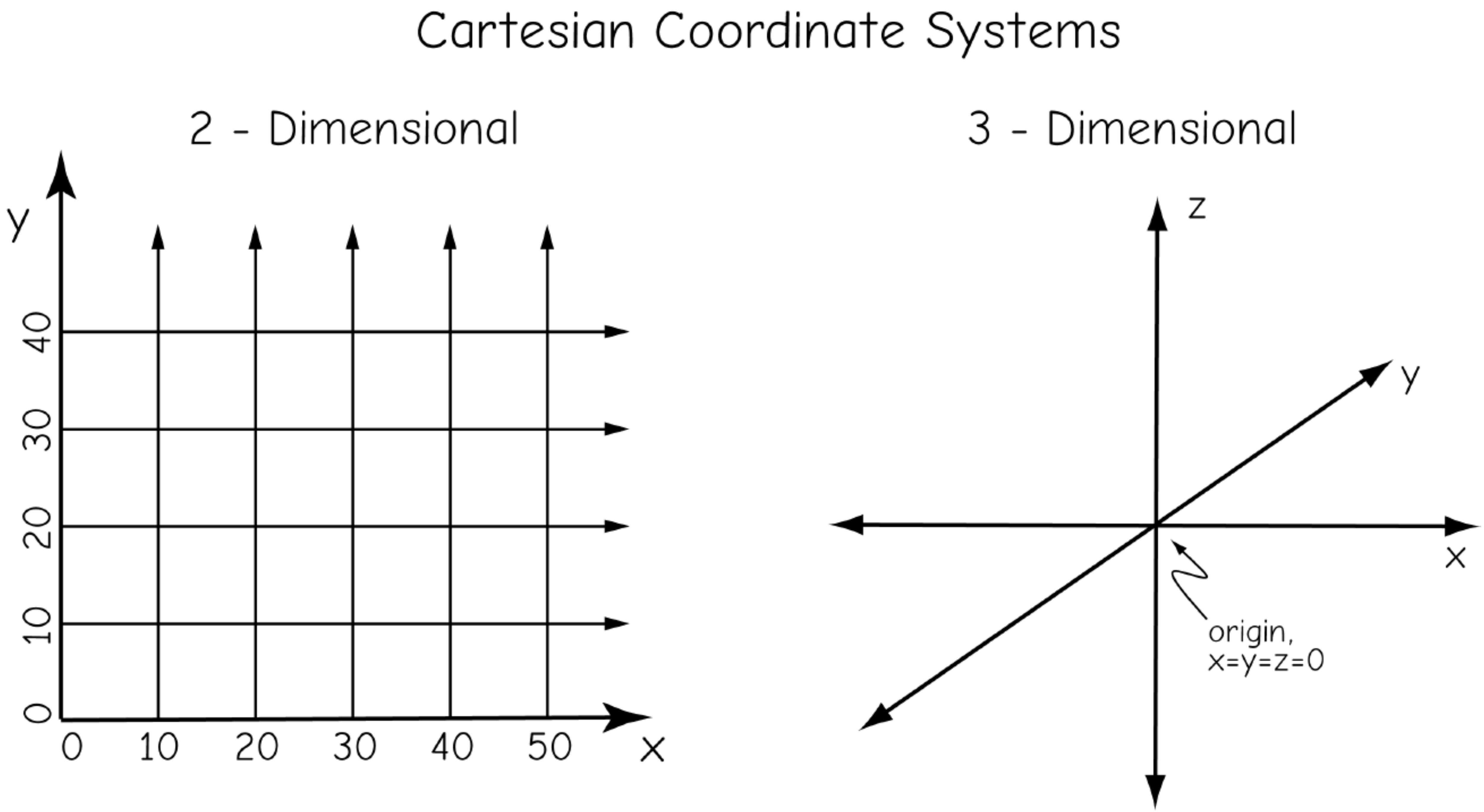
$$1 = \frac{(x-x_o)^2}{a^2} + \frac{(y-y_o)^2}{b^2}$$



Our System References Rotational North Pole, not A Wandering Magnetic North Pole



Most of Our GIS Layers Stored, Manipulated in Cartesian Coordinate Systems



Introduction to Data Models

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Data models are an intermediate abstraction, between the real world and computer code

We primarily use Cartesian coordinates to store our data in layers, but features on the Earth are best located using spherical coordinates

Spherical coordinates aren't "well behaved" when treated like Cartesian coordinates - longitudes converge, only one "straight line" distance is correct