REPRESENTING LOCATION AND COORDINATE SYSTEMS

CLASS #5 | GEOG 215

Introduction to Spatial Data Science

Spring 2020

TODAY'S CLASS

- How do we represent location?
- Reference systems
- Geographic coordinate reference systems
- Projected coordinate reference systems
- Types of Spatial Data

WHAT IS (GEO–) SPATIAL DATA SCIENCE ?

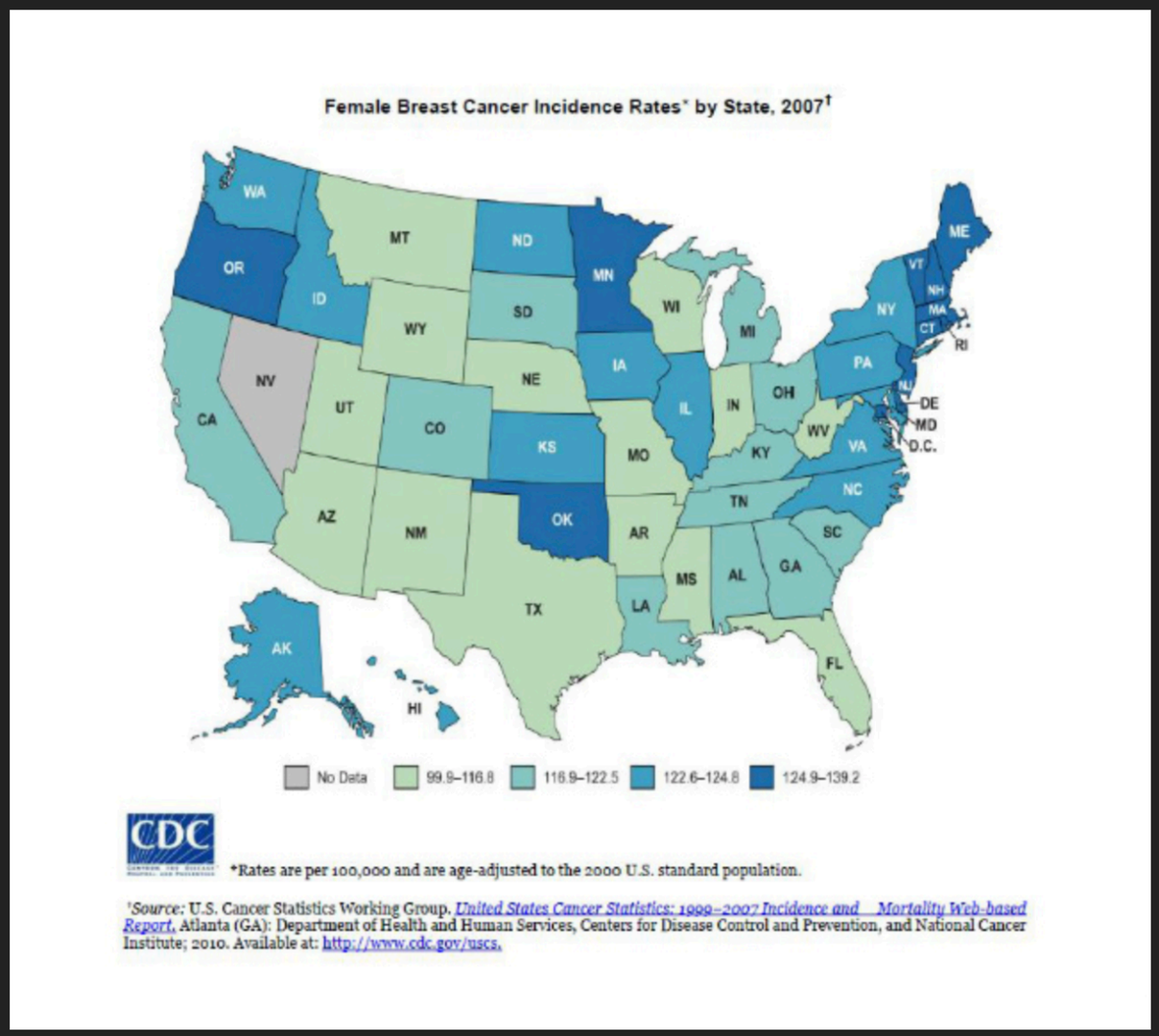
- Similar to (subset of) Data Science
  - Focus on observations/data that are geo-referenced to a location on Earth's surface
    - Have a defined location
- Focus on answers and understanding spatial/geographic questions, e.g.,
  - Where?
  - Why there?

SPATIAL DATA IS SPECIAL

- Linked geometric and tabular data
  - Position and attributes
    - Geometric data is NOT the same as adding a "location" name or coordinate values
- Enables simultaneous spatial and statistical analysis
  - May provide causal insights that otherwise won't be visible

MOVING FROM TABULAR TO SPATIAL

	White		African American	
State	Incidence	Mortality	Incidence	Mortality
Alabama	115.6	24.5	103.8	31.6
Alaska	132.4	22.3	117.7	30.0
Arizona†	116.6	23.6	80.6	36.9
Arkansas†	117.4	22.8	102.3	34.9
California	133.3	25.0	118.1	33.7
Colorado	129.9	23.4	100.1	21.7
Connecticut	139.9	25.2	112.9	26.9
Delaware	126.9	25.3	117.5	32.7
Dist. of Columbia	153.0	26.7	122.9	36.1
Florida	122.0	22.8	101.7	30.5
Georgia	127.8	24.0	113.3	30.8
Hawaii	144.8	22.9	74.7	‡
Idaho	124.2	23.7	§	‡
Illinois	127.3	25.5	119.2	38.9
Indiana	121.2	25.7	109.6	34.2
Iowa	125.7	23.4	109.3	37.2
Kansas	§	24.6	§	37.9
Kentucky	121.0	25.5	129.8	36.6
Louisiana	121.6	25.7	123.7	40.3
Maine	130.2	23.7	101.7	‡
Maryland	§	25.9	§	34.0
Massachusetts	138.9	26.0	95.2	26.3
Michigan	129.9	24.6	119.0	35.0
Minnesota	§	24.1	§	26.1
Mississippi†	105.0	24.1	102.7	36.3
Missouri	125.0	25.7	117.2	36.5



COMPONENTS OF SPATIAL DATA

- Location
  - Often in 2-D space, but can be 3-D
- Attribute
  - Some measurable or observable property
- Time
  - Maps can be a snapshot, or be variable over time
- Metadata
  - Describes the data and assumption

LOCATION

- **Absolute**
  - Exact location on Earth
  - Requires a *reference system*
    - The underlying system defining all potential/possible locations
- **Most common, latitude and longitude**
  - Interestingly, there are numerous versions of this reference system.

LOCATION

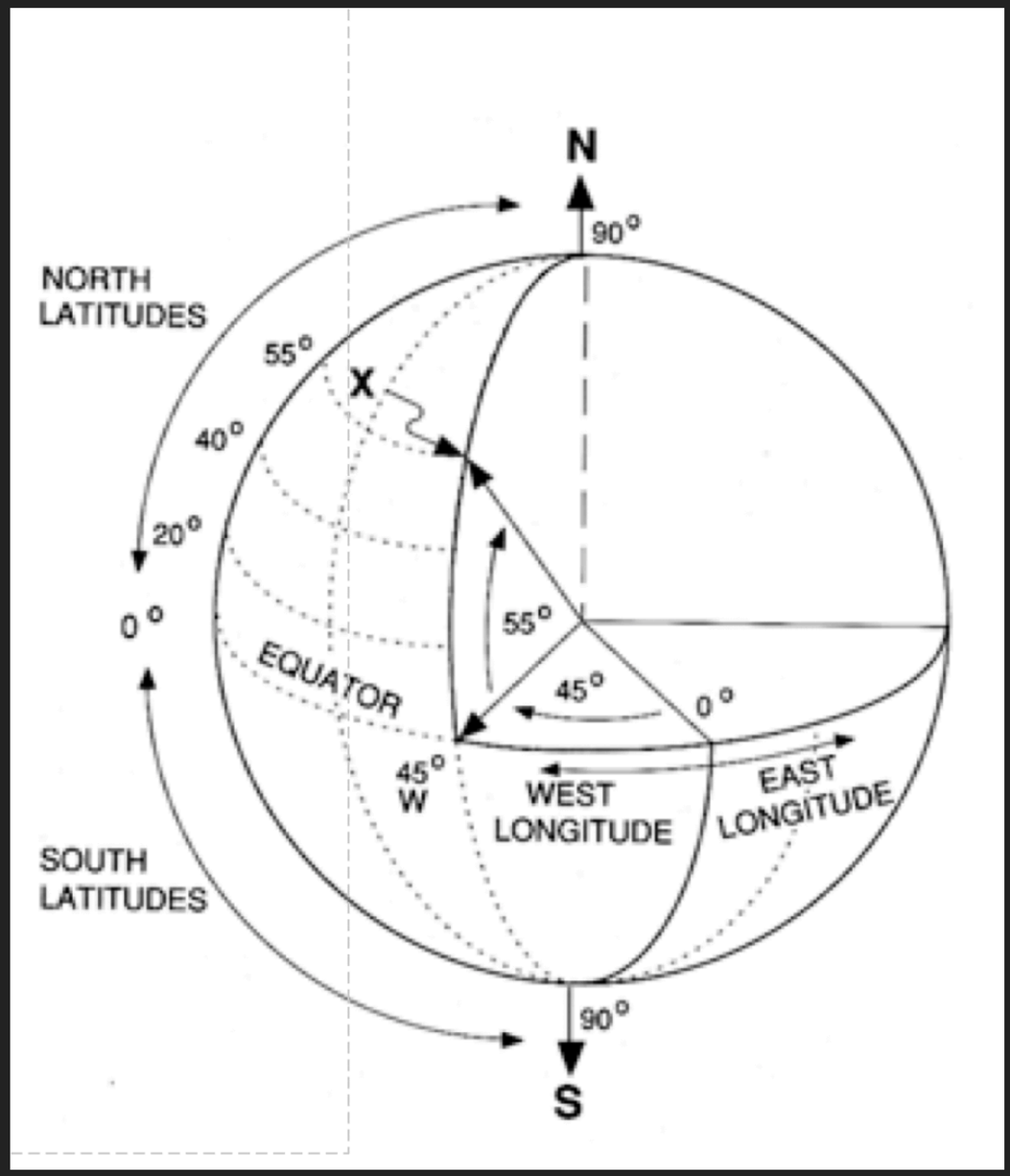
- **Relative**
  - Location, relative to others
    - Often used for navigation
    - Can use cardinal directions
      - E.g, Chapel Hill is location east of Asheville
- Can use exact or relative distance
  - E.g, Chapel hill is located 28.2 miles from Raleigh
  - Chapel Hill is located near Durham
- Can be non geographic
  - This classroom is opposite from my office

TYPICAL REFERENCE SYSTEMS

- **Street network**
  - Location defined as address
  - Useful because of constrained nature of travel
  - Places “off” network not definable
- **Geographic coordinate system**
  - Location defined as latitude and longitude
  - All places on Earth are defined
- **Informal systems**
  - Place names, e.g., Chapel Hil

GEOGRAPHICAL REFERENCE SYSTEM

- On a sphere, referencing is made using angles, using the center of earth as the origin.
- **Latitude**
  - Measured N-S relative to Equator
- **Longitude**
  - Measured E-W relative to Prime Meridian



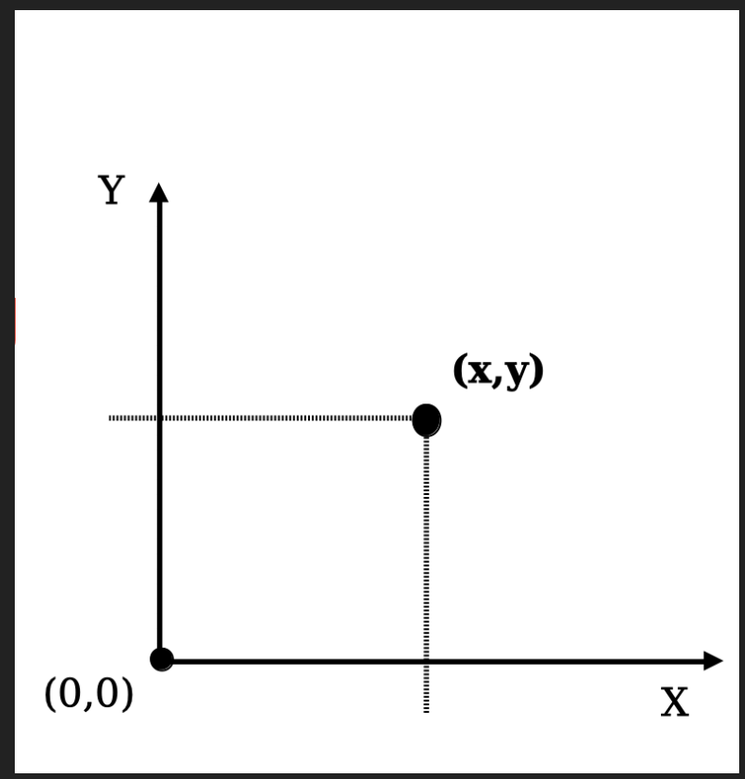
GEOGRAPHICAL REFERENCE SYSTEM

- Most common units:
  - **Decimal degrees**
    - Carolina Hall is 35.911202°N, -79.049924°W
  - **Degrees-Minutes-Seconds**
    - 35°54'40"N 79°02'59"W
- Conversions:
  - 1 degree = 60 minutes (‘)
  - 1 minute = 60 seconds (“)

Which is more machine-readable?

CARTESIAN REFERENCE SYSTEMS

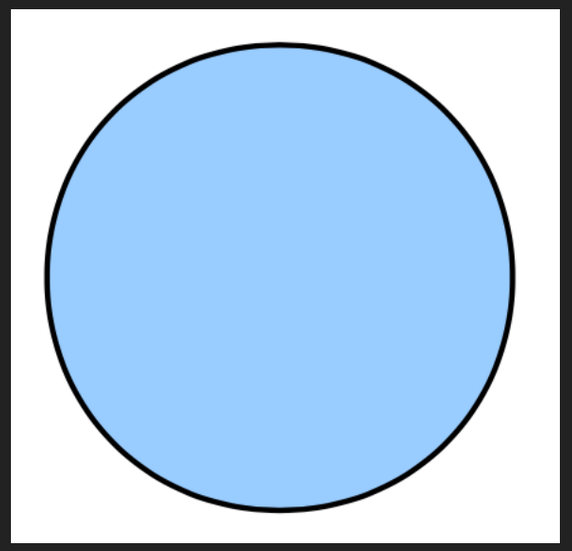
- Cartesian reference systems, also referred to as “projected reference systems”
  - Location referenced relative to two perpendicular axes (X,Y)
  - Measurements are in distance along each axis from the origin (0,0)
  - **Most common units:**
    - English: inches, feet
    - Metric: centimeters, meters, kilometers



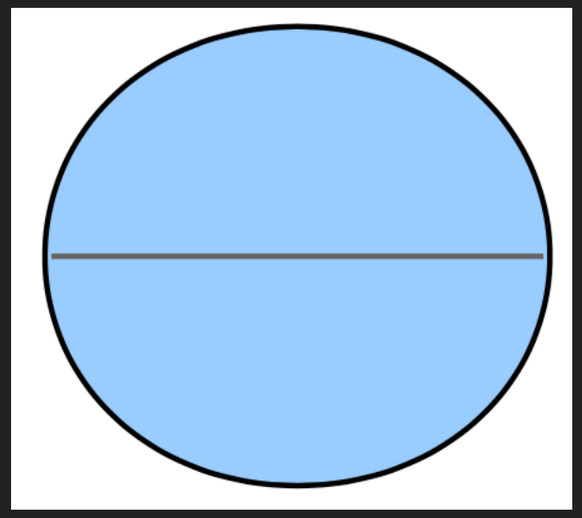
WHICH SHAPE MOST CLOSELY RESEMBLES EARTH

A

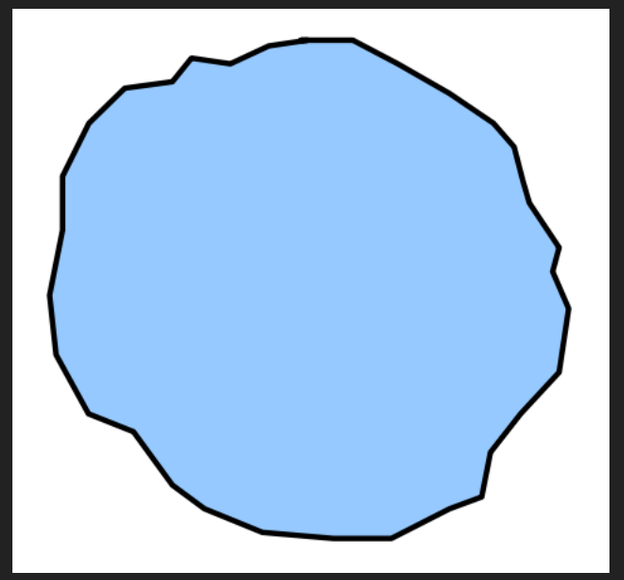
B



C



D



Which shape, according to you, most closely represents Earth

A

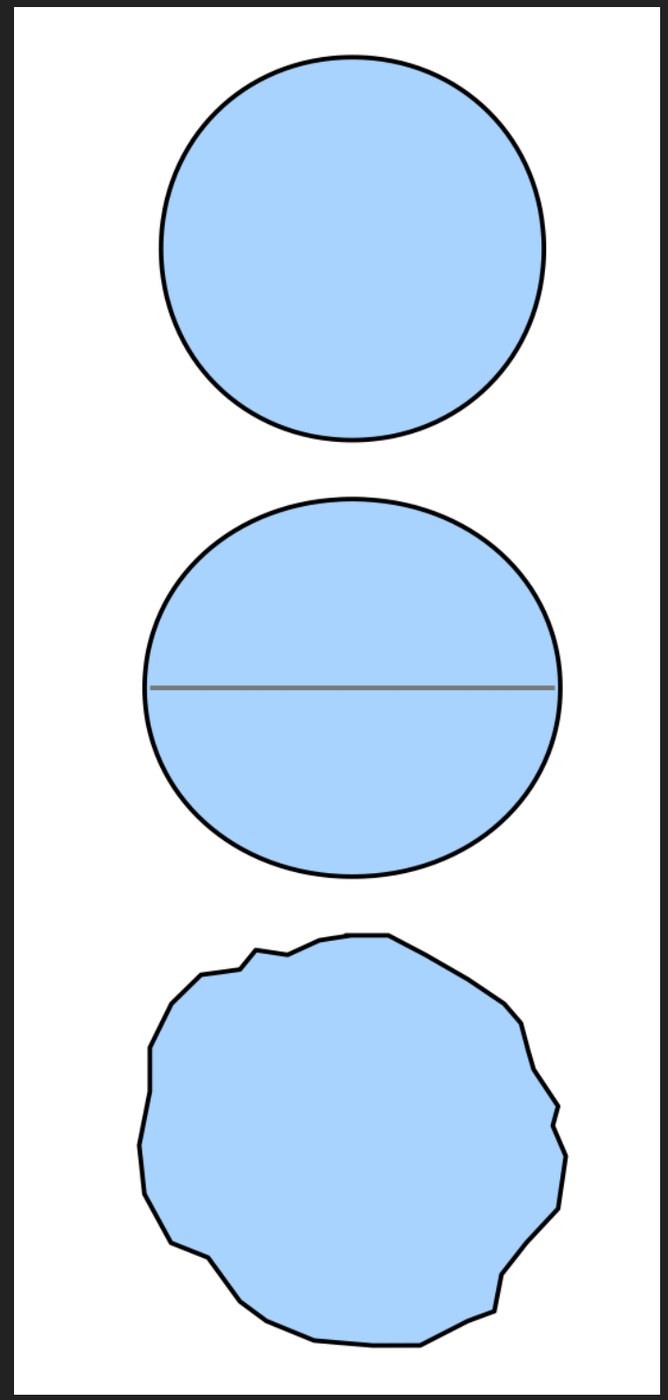
B

C

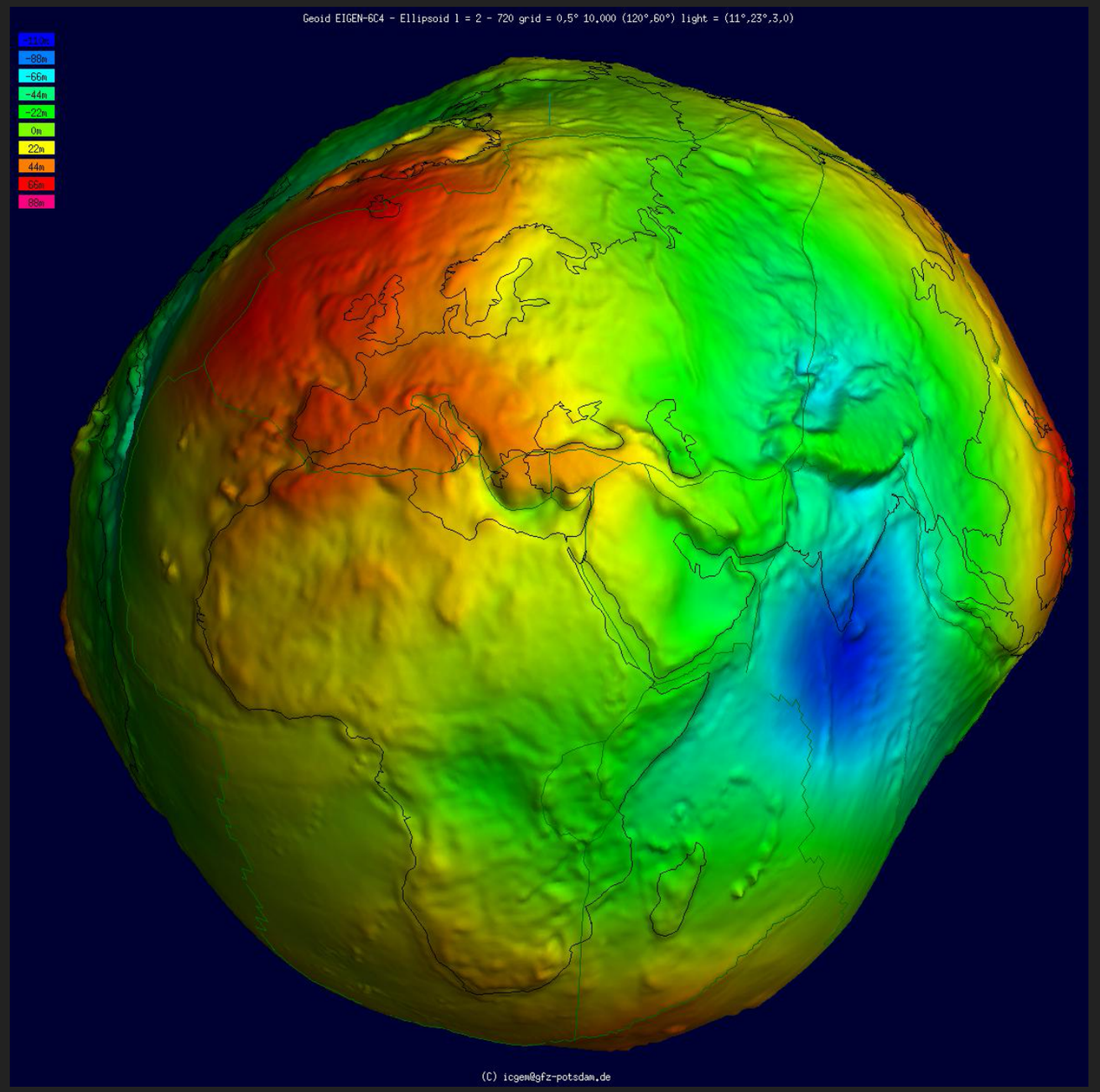
D

SHAPE OF THE EARTH

- **Sphere**
  - Assumes perfectly spherical Earth
  - Not realistic
- **Ellipsoid**
  - Assumes flattening at poles, bulging at equator, described by flattening ratio
- **Geoid**
  - Accounts for gravitational variations across Earth's surface (i.e, variations in "sea level")
    - An observed quantity that measures deviation from ellipsoid



EARTH AS A GEOID



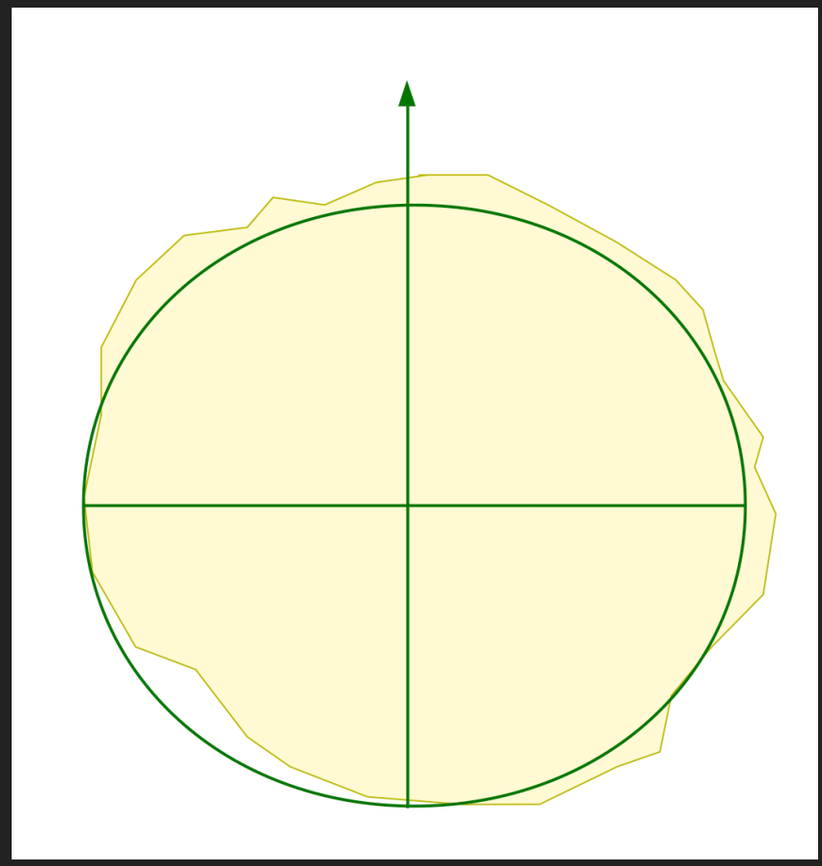
DATUM

Model of the shape/size of the Earth

- Consists of an ellipsoid, defined by its size and shape
- Fit to the earth (original location)
  - Many are created for use only in specific areas of the earth
  - i.e., ellipsoid is fitted to only a portion of the earth and the center of the Earth is shifted in each
  - Ellipsoid is referenced to a point on the Earth surface
- World Geodetic System (WGS84) is referenced to the center of Earth and designed for use globally

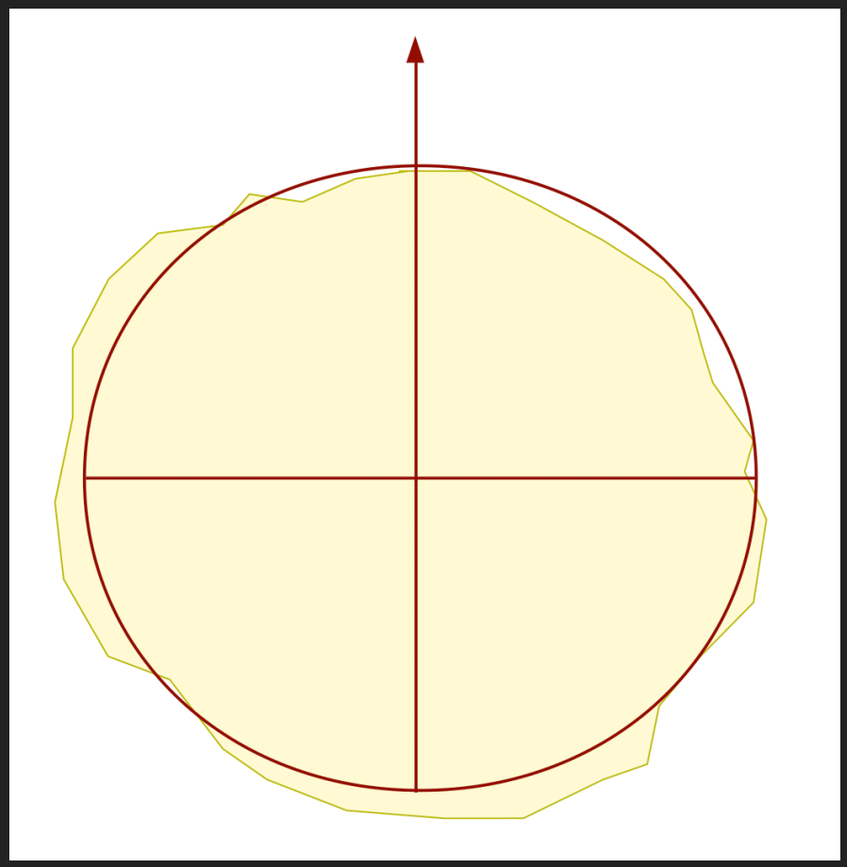
DATUM TYPES

- NAD 27
  - Clarke 1866 ellipsoid
  - Best fit to North America



DATUM TYPES

- NAD 27
  - Clarke 1866 ellipsoid
  - Best fit to North America
- WGS 84
  - GRS80 Ellipsoid
    - Origin is center of Earth's Mass
  - Best fit to globe



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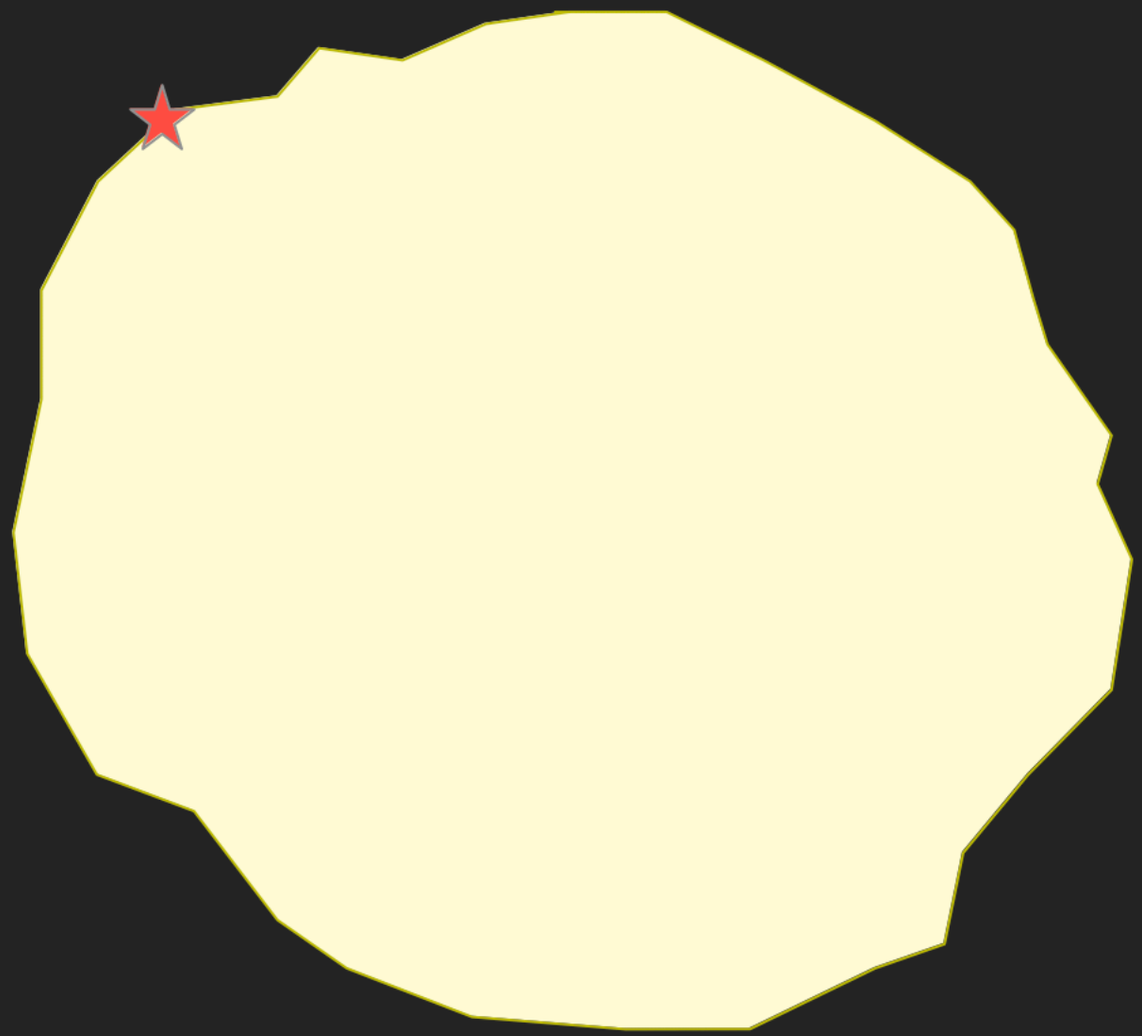
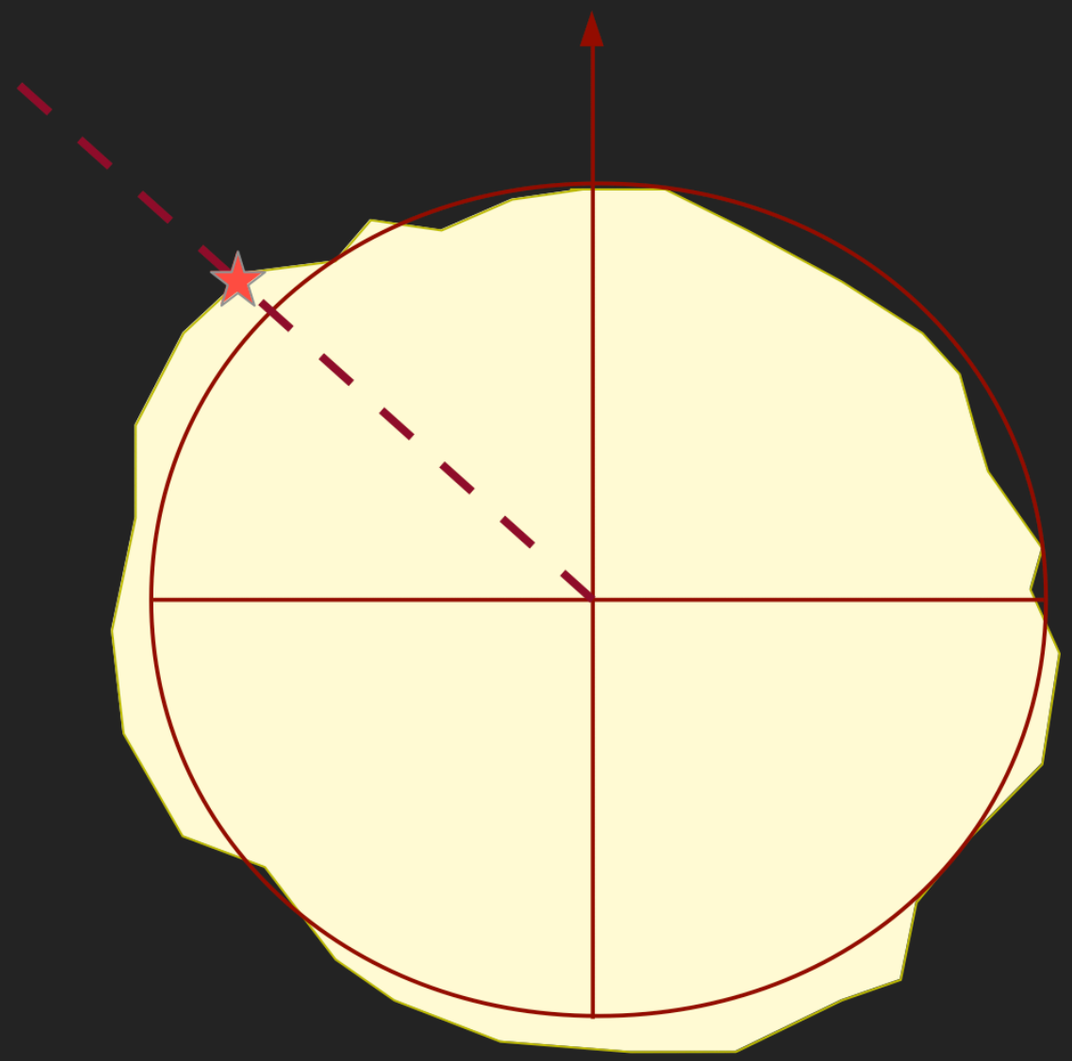
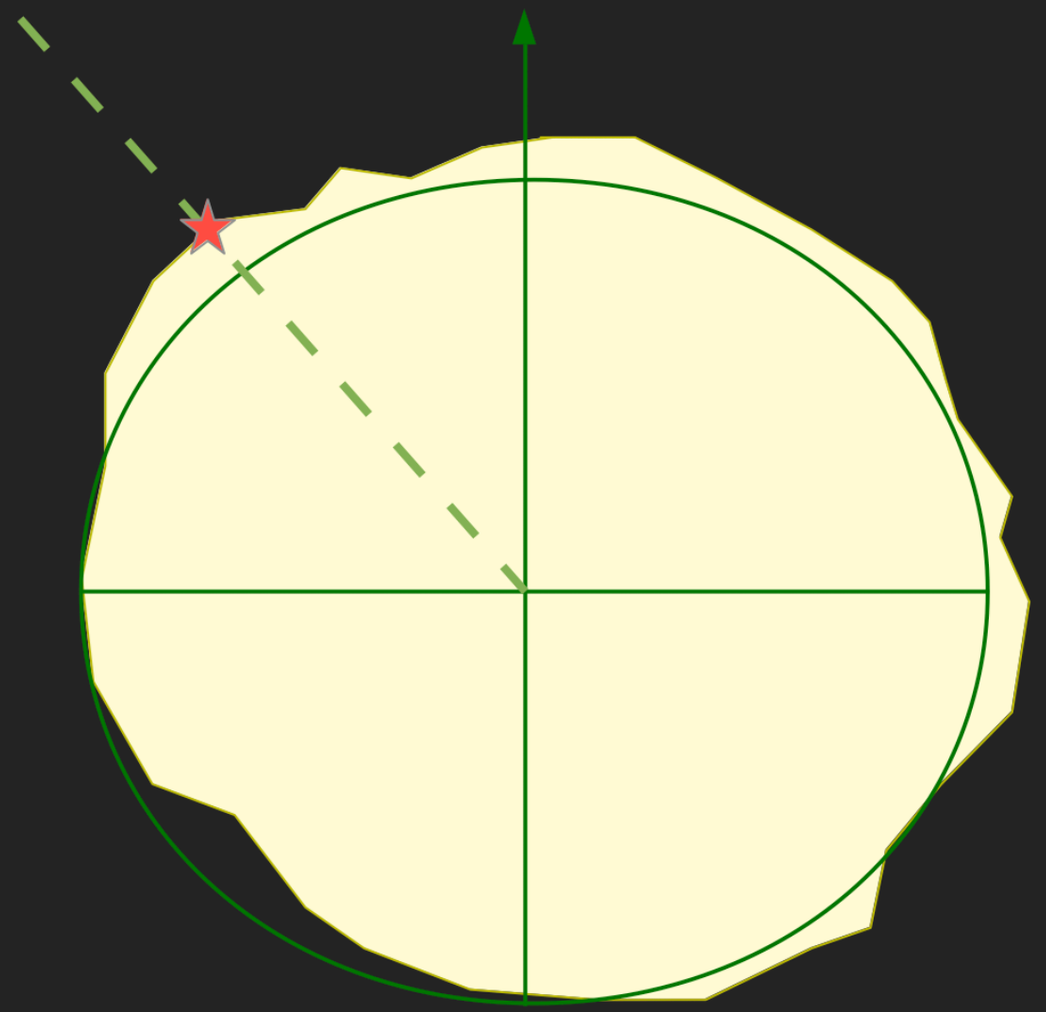
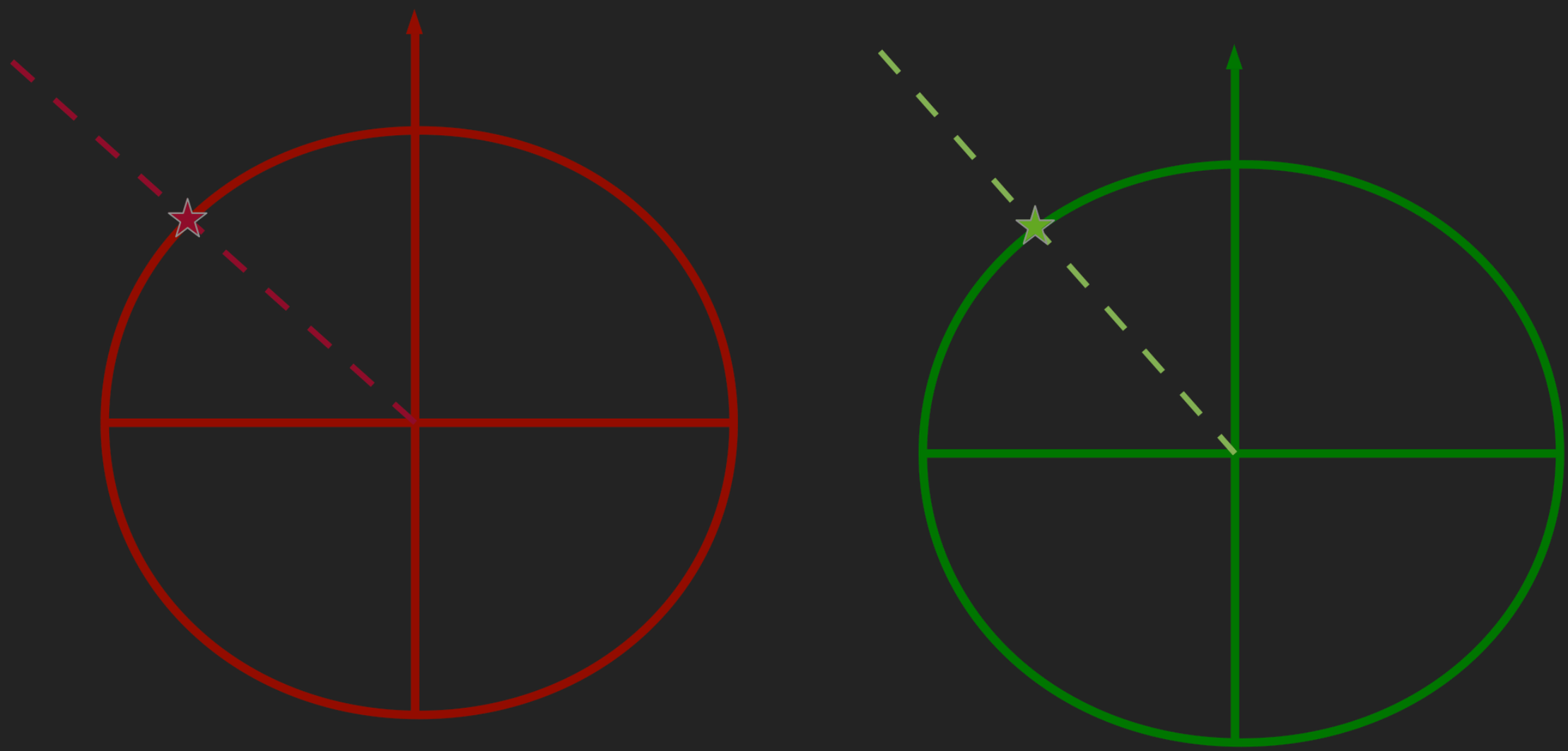


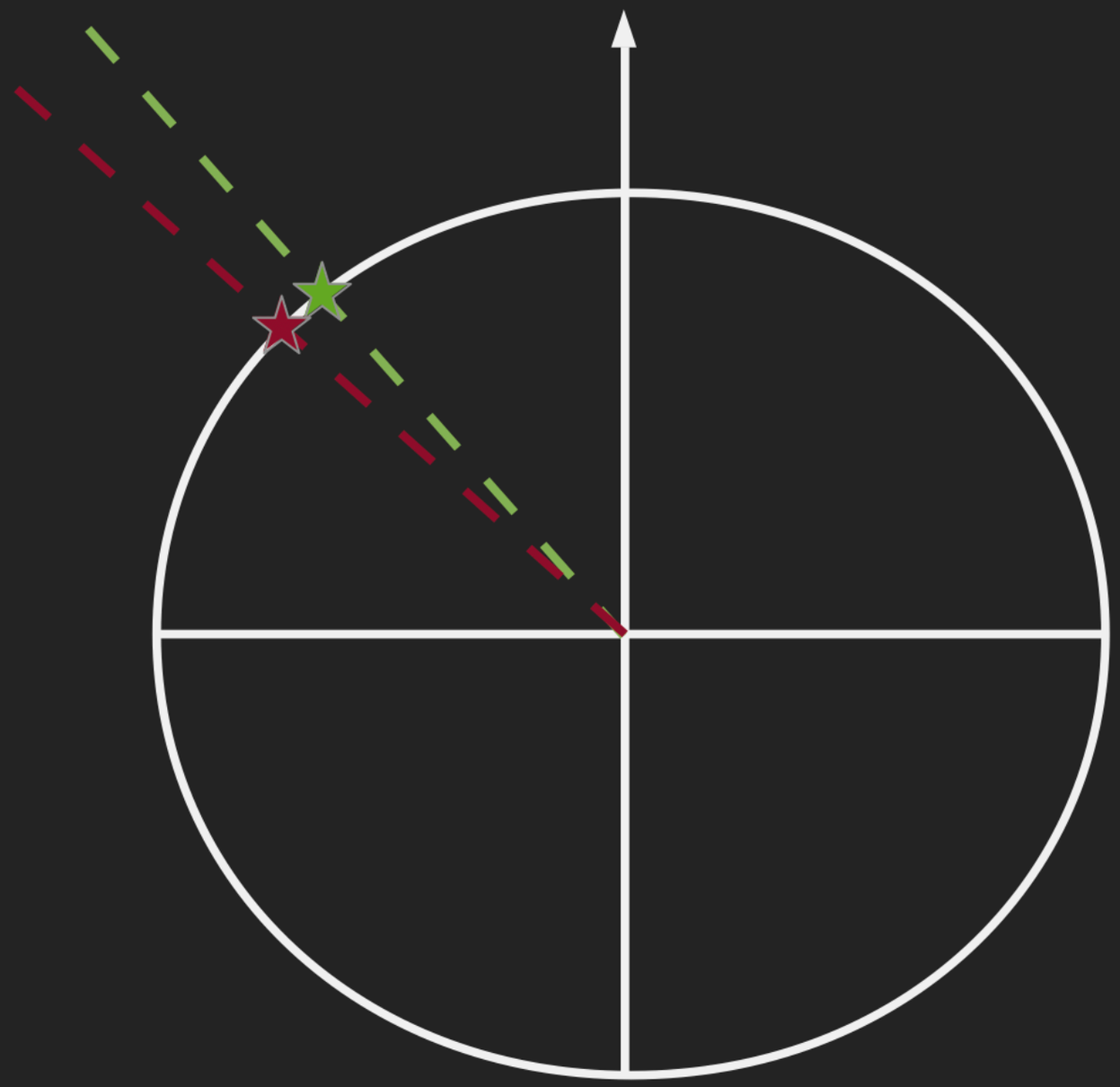
DATUM



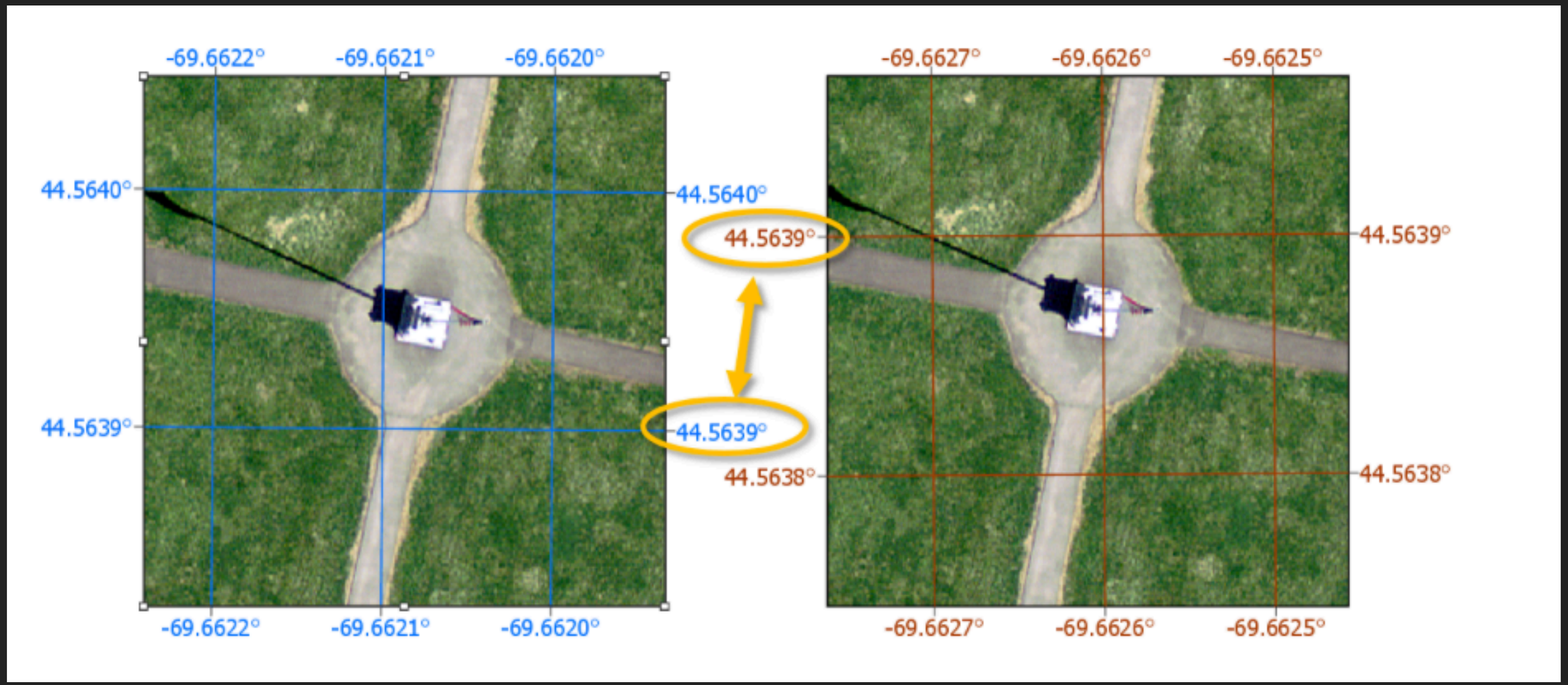


DATUM





DATUM


-69.6622°
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-69.6626°
-69.6625°
44.5639°
44.5638°
44.5638°
-69.6627°
-69.6626°
-69.6625°

GEOGRAPHIC COORDINATE SYSTEM COMPONENTS

- **Datum**
  - Defined ellipsoid (and location)
- **An origin**
  - Prime Meridian or Equator
- **Units**
  - Angles: decimal degrees, degrees minutes seconds

Geographic Coordinate Systems and Datums are nearly the same thing

What Type of Measurement levels are latitudes and longitudes in a Geographic Coordinate System?

Nominal

Ordinal

Interval

Ratio

Circular

Not Sure

EXERCISE

OPEN GOOGLE MAPS ON YOUR COMPUTER

World Maps Quiz

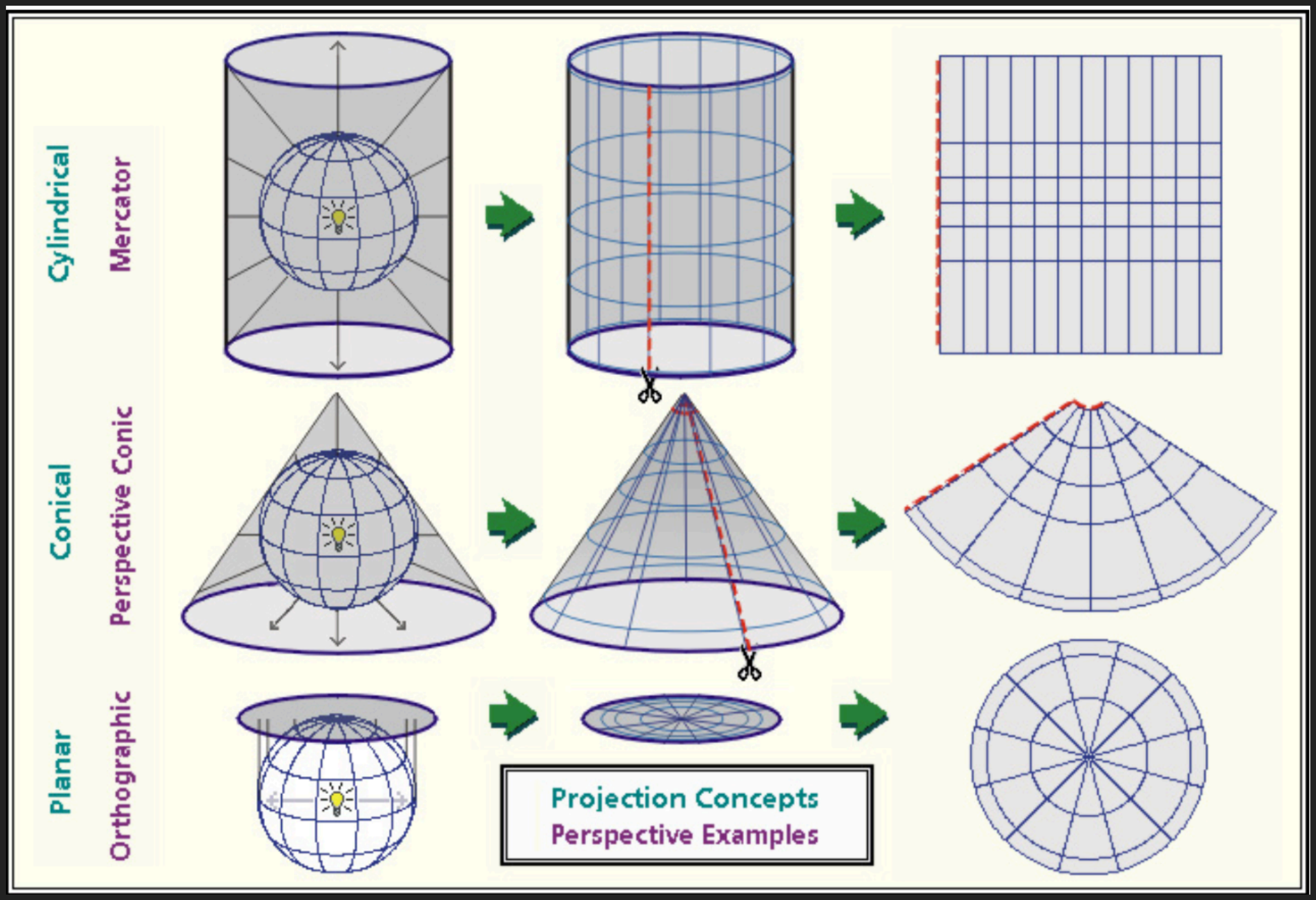
When survey is active, respond at **PollEv.com/goelvarun553**

0 surveys done

0 surveys underway

PROJECTED COORDINATE SYSTEMS

- Also called “Projections”
- Mathematically defined conversions from location on 3-D Earth to 2-D space
- Use geometric analogy of light source shining through clear Earth onto a “developable surface”
- Distortion increases away from point of contact
- Two most common developable surfaces
  - Cylindrical and Conic

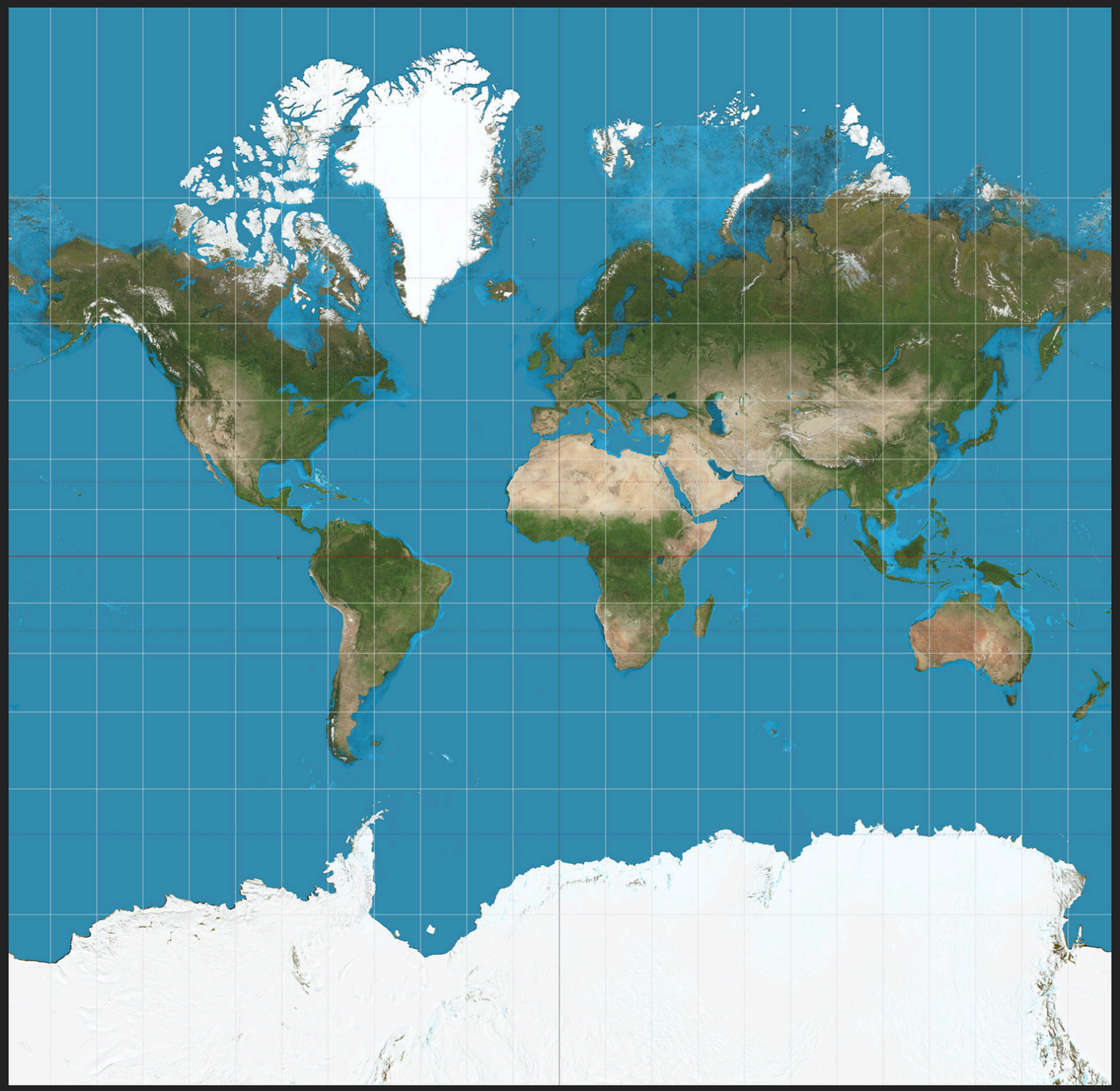

Cylindrical
Mercator
Conical
Perspective Conic
Planar
Orthographic
Projection Concepts
Perspective Examples

PROJECTED COORDINATE SYSTEMS

- Properties of the Earth or “features”
- **Direction, shape, area, distance**
- Projected coordinate systems distort some or all of these properties
  - Necessary because of the nature of moving from a 3D system to a 2D system
  - Remember, projections are mathematical transformations from angular coordinates
  - No perfect transformation
    -

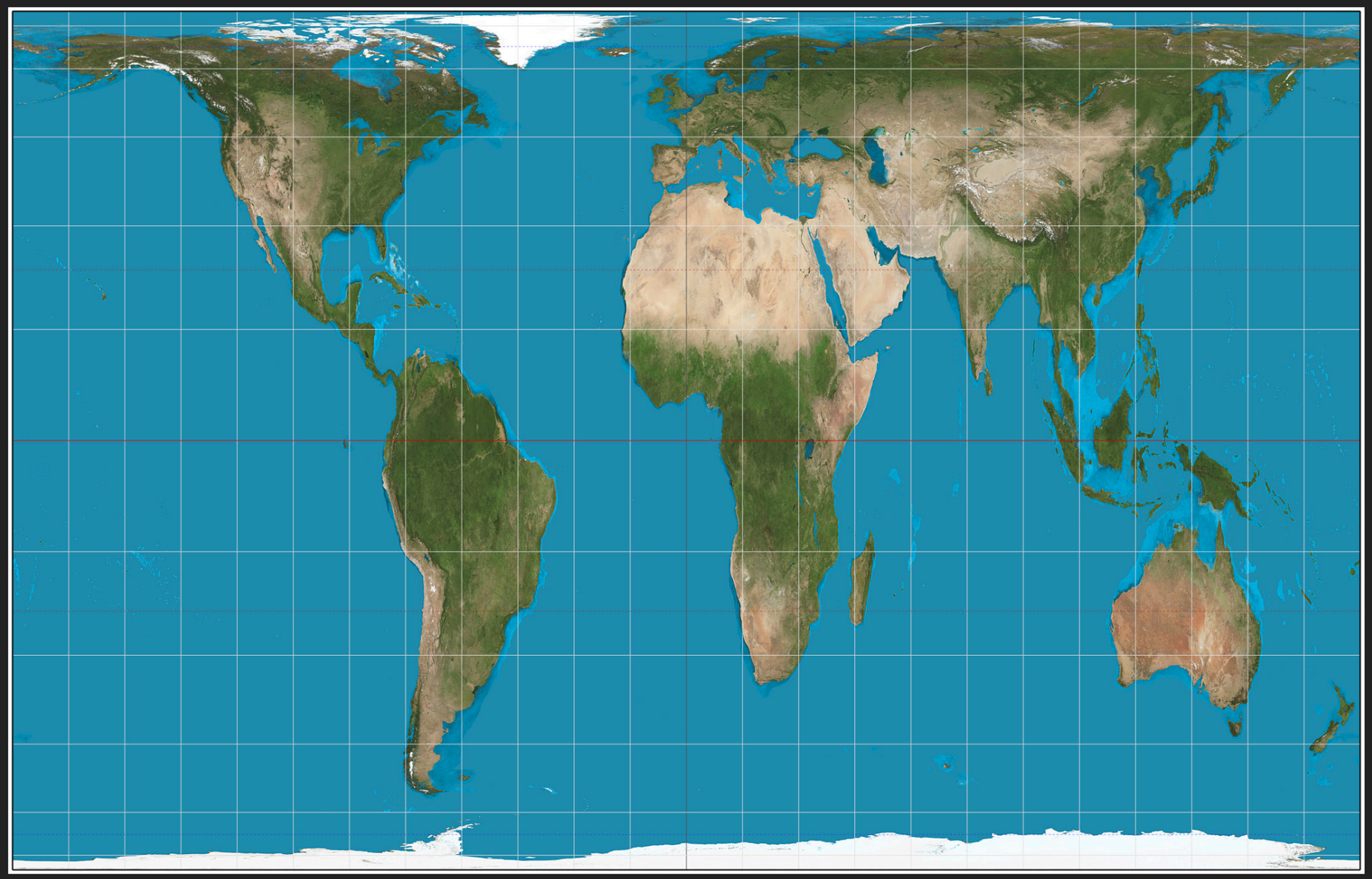
EXAMPLES OF DIFFERENT PROJECTIONS

Mercator Projection



EXAMPLES OF DIFFERENT PROJECTIONS

Gall Peters Projection



EXERCISE

https://thetruesize.com/

The **True Size** of **Africa**

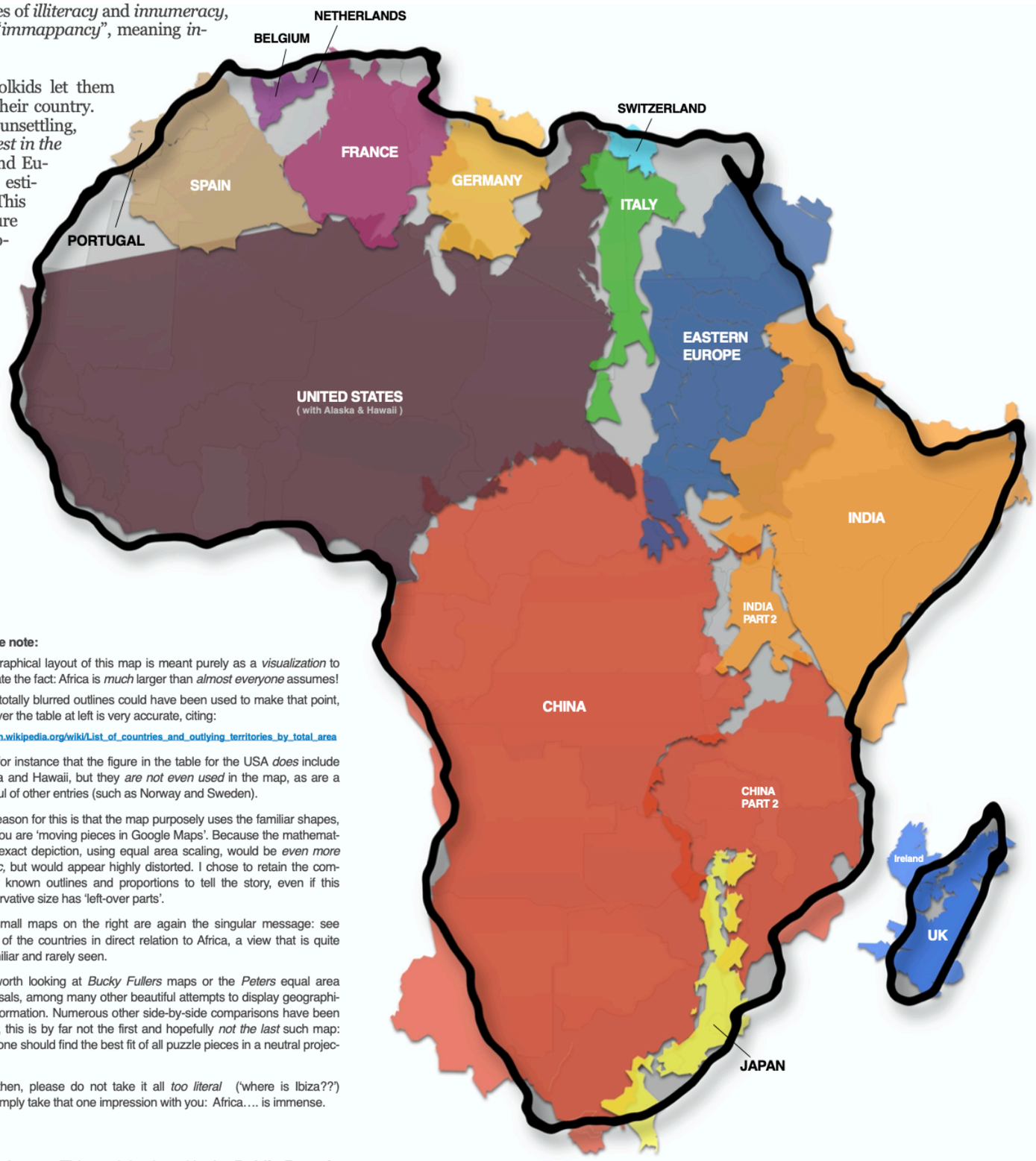
A small contribution in the fight against rampant *Immappancy*, by **Kai Krause**

In addition to the well known social issues of *illiteracy* and *innumeracy*, there also should be such a concept as "*immappancy*", meaning *insufficient geographical knowledge*.

A survey with random American schoolkids let them guess the population and land area of their country. Not entirely unexpected, but still rather unsettling, the majority chose *"1-2 billion"* and *"largest in the world"*, respectively. Even with Asian and European college students, geographical estimates were often off by factors of *2-3*. This is partly due to the highly distorted nature of the predominantly used mapping projections (such as *Mercator*).

A particularly extreme example is the worldwide misjudgement of the true size of Africa. This single image tries to embody the massive scale, which is larger than the *USA*, *China*, *India*, *Japan* and *all of Europe - combined!*

COUNTRY	AREA x 1000 km²
USA	9.629
China	9.573
India	3.287
Mexico	1.964
Peru	1.285
France	633
Spain	506
Papua New Guinea	462
Sweden	441
Japan	378
Germany	357
Norway	324
Italy	301
New Zealand	270
United Kingdom	243
Nepal	147
Bangladesh	144
Greece	132
TOTAL	**30.102**
AFRICA	**30.221**
Just for Reference: The Surface of the MOON	37.930



Please note:

The graphical layout of this map is meant purely as a *visualization* to illustrate the fact: Africa is *much* larger than *almost everyone* assumes!

Even totally blurred outlines could have been used to make that point, however the table at left is very accurate, citing:

http://en.wikipedia.org/wiki/List_of_countries_and_outlying_territories_by_total_area

Note for instance that the figure in the table for the USA *does* include Alaska and Hawaii, but they *are not even used* in the map, as are a handful of other entries (such as Norway and Sweden).

The reason for this is that the map purposely uses the familiar shapes, as if you are 'moving pieces in Google Maps'. Because the mathematically exact depiction, using equal area scaling, would be *even more drastic*, but would appear highly distorted. I chose to retain the commonly known outlines and proportions to tell the story, even if this conservative size has 'left-over parts'.

The small maps on the right are again the singular message: see some of the countries in direct relation to Africa, a view that is quite unfamiliar and rarely seen.

It is worth looking at *Bucky Fullers* maps or the *Peters* equal area proposals, among many other beautiful attempts to display geographical information. Numerous other side-by-side comparisons have been made, this is by far not the first and hopefully *not the last* such map: someone should find the best fit of all puzzle pieces in a neutral projection.

Until then, please do not take it all *too literal* ('where is Ibiza??') and simply take that one impression with you: Africa…. is immense.

Top 100 Countries

Area in square kilometers, Percentage of World Total
Sources: Britannica, Wikipedia, Almanac 2010


United States


Europe


India


Japan


China

Source: http://kai.sub.blue/images/True-Size-of-Africa-kk-v3.pdf

PROJECTED COORDINATE SYSTEM COMPONENTS

- **A Geographic Coordinate System**
  - Datum, with origin and units
- **A projection**
  - Developable Surface (such as cylindrical, conical, others
- **An origin**
  - (x,y) = (0,0)
- **Units**
  - Distance: meters, feet

WHY ARE PROJECTIONS IMPORTANT?

WHY ARE PROJECTIONS IMPORTANT?

North Korea

When bluff turns deadly

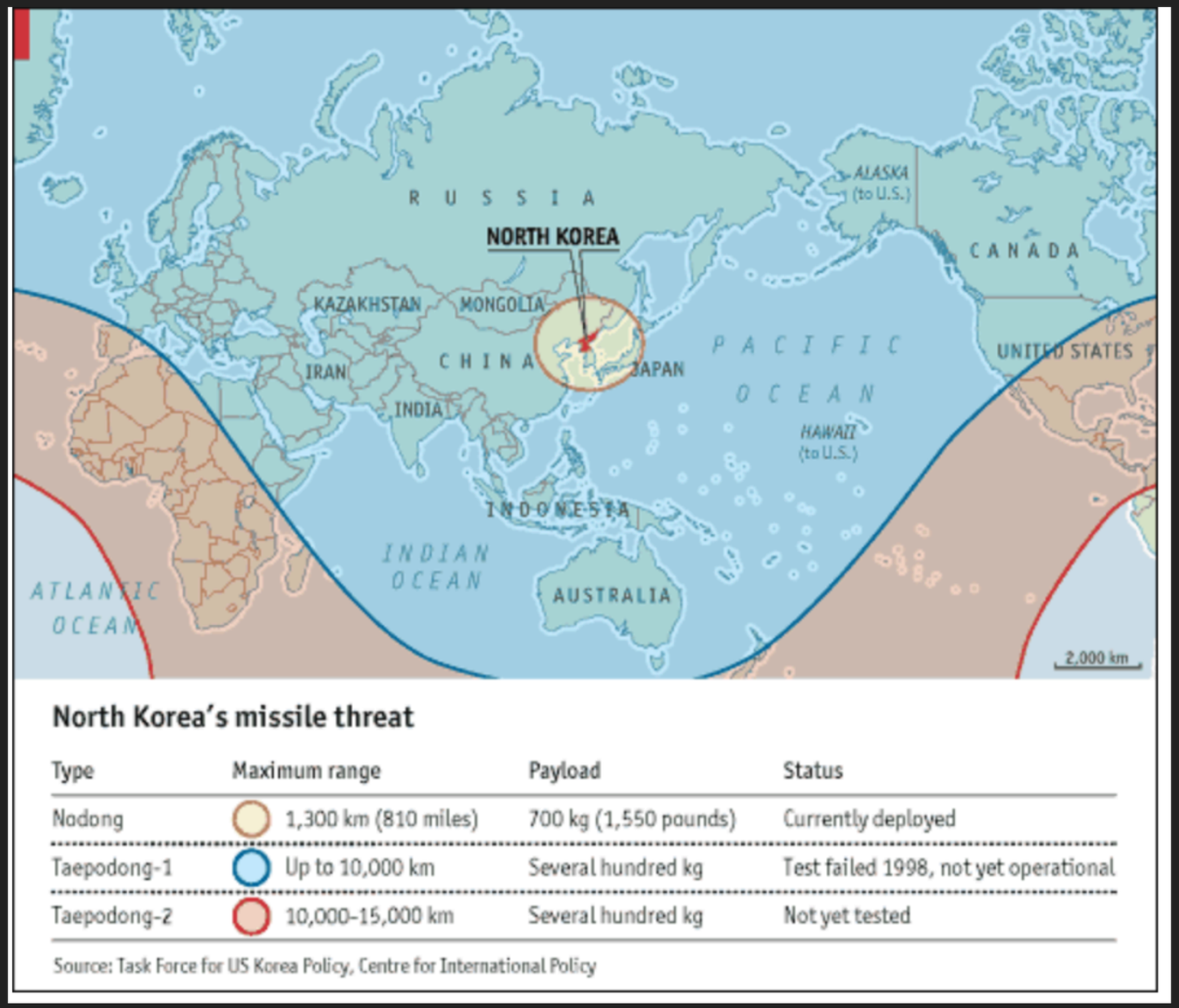
If diplomacy cannot work, what then?

North Korea's missile threat

Type	Maximum range	Payload	Status
Nodong	1,300 km (810 miles)	700 kg (1,550 pounds)	Currently deployed
Taepodong-1	Up to 10,000 km	Several hundred kg	Test failed 1998, not yet operational
Taepodong-2	10,000-15,000 km	Several hundred kg	Not yet tested

Source: Task Force for US Korea Policy, Centre for International Policy

MAPS CAN LIE



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Flat-earth thinking. Thank you to those readers who pointed out that, by superimposing concentric circles on a Mercator projection, the map in our May 3rd issue (now corrected online) greatly underestimated the potential reach of North Korea's missiles. We stand corrected.

RIGHT NOW, FOR THIS CLASS……

- All spatial data has a coordinate system, or must be assigned one
- Difference between geographic and projected (Cartesian) coordinates
  - Geographic: 3 dimensions, angles
  - Cartesian: 2 dimensions, distance
- **Important to know the coordinate system of data you are working with !!!**

HOW IS LOCATION REPRESENTED IN DATA

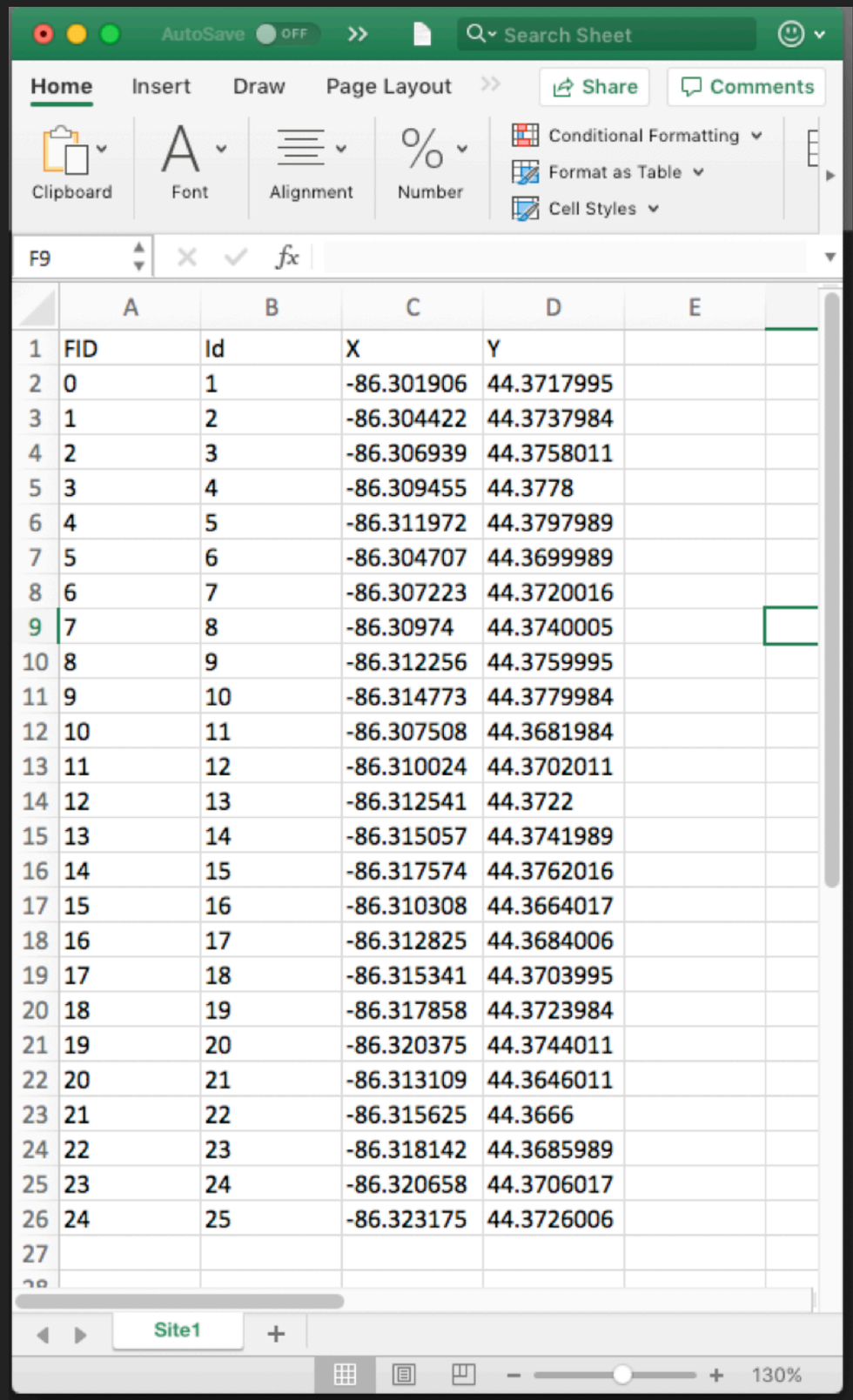
Latitude, Longitude

- Most common format for representing location
- Often represented in tables
- Can be converted to spatial data

WHAT DOES X REPRESENT?

WHAT DOES Y REPRESENT?

DO THESE REPRESENT POINTS, LINES, POLYGONS ?



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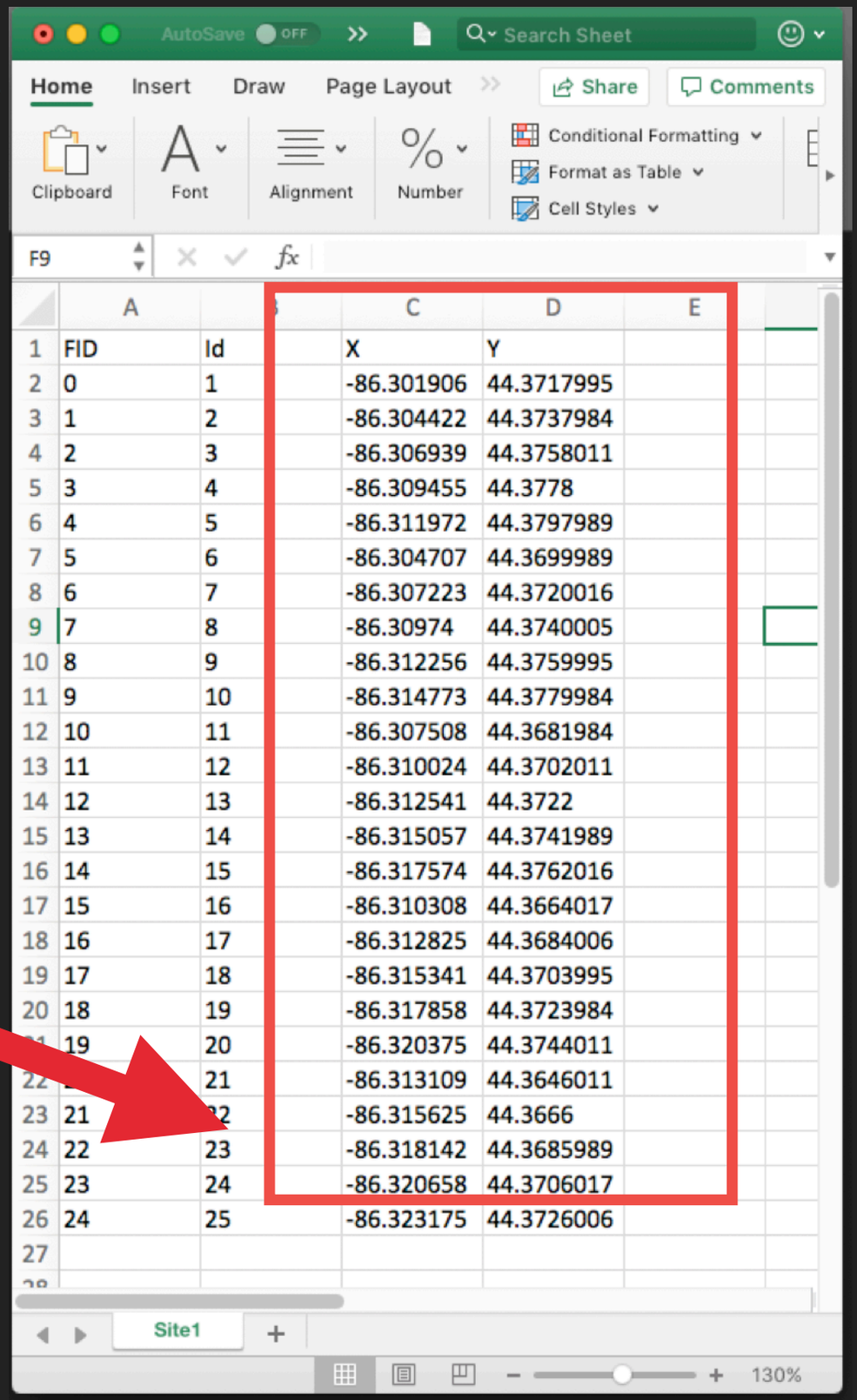
3	1	2	-86.304422	44.3737984	
4	2	3	-86.306939	44.3758011	
5	3	4	-86.309455	44.3778	
6	4	5	-86.311972	44.3797989	
7	5	6	-86.304707	44.3699989	
8	6	7	-86.307223	44.3720016	
9	7	8	-86.30974	44.3740005	
10	8	9	-86.312256	44.3759995	
11	9	10	-86.314773	44.3779984	
12	10	11	-86.307508	44.3681984	
13	11	12	-86.310024	44.3702011	
14	12	13	-86.312541	44.3722	
15	13	14	-86.315057	44.3741989	
16	14	15	-86.317574	44.3762016	
17	15	16	-86.310308	44.3664017	
18	16	17	-86.312825	44.3684006	
19	17	18	-86.315341	44.3703995	
20	18	19	-86.317858	44.3723984	
21	19	20	-86.320375	44.3744011	
22	20	21	-86.313109	44.3646011	
23	21	22	-86.315625	44.3666	
24	22	23	-86.318142	44.3685989	
25	23	24	-86.320658	44.3706017	
26	24	25	-86.323175	44.3726006	
27					

HOW IS LOCATION REPRESENTED IN DATA

Latitude, Longitude

- Most common format for representing location
- Often represented in tables
- Can be converted to spatial data

IMPORTANT TO KNOW WHAT THE COORDINATE SYSTEM IS



	A		C	D	E
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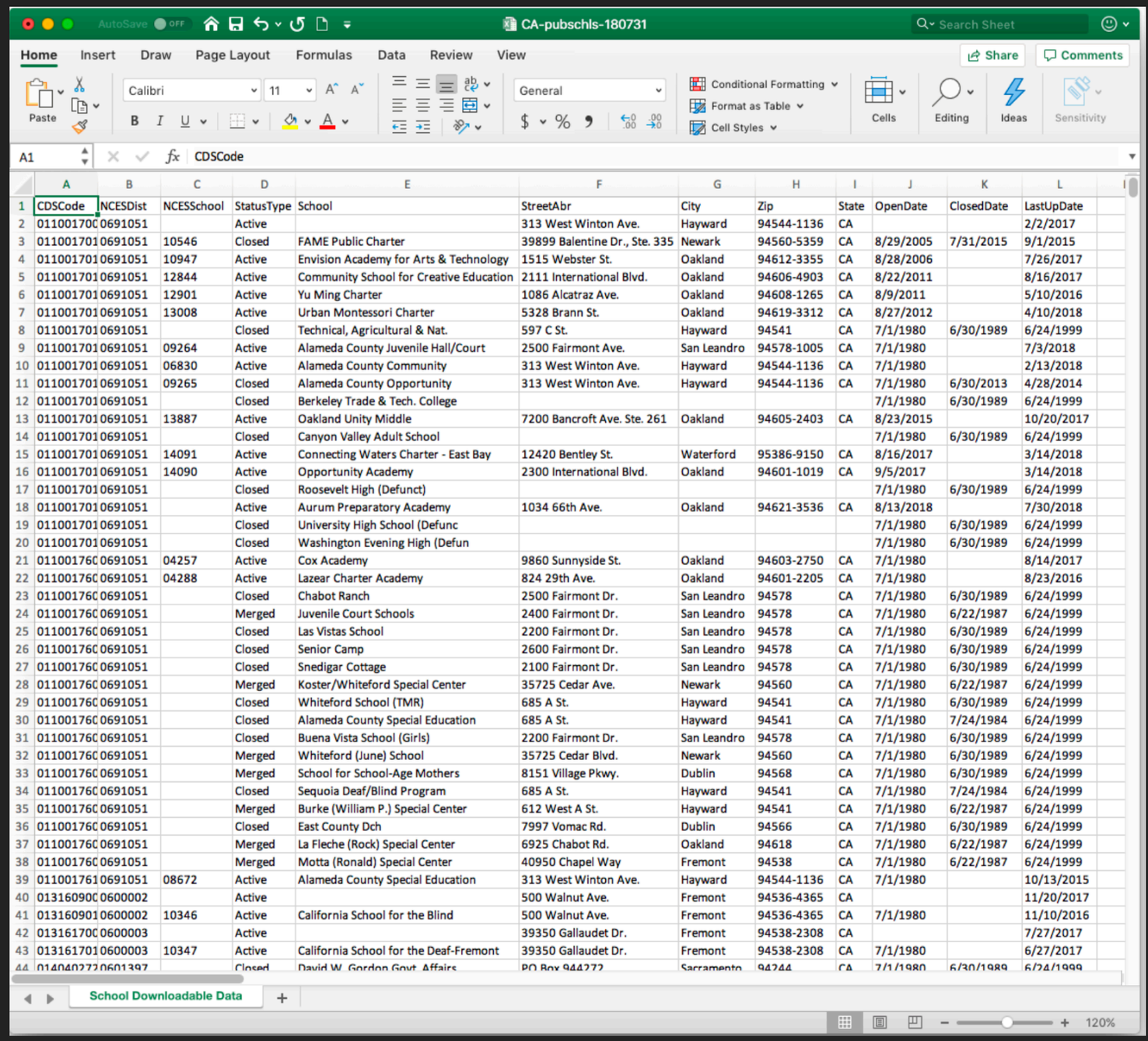
6	4	5	-86.311972	44.3797989	
7	5	6	-86.304707	44.3699989	
8	6	7	-86.307223	44.3720016	
9	7	8	-86.30974	44.3740005	
10	8	9	-86.312256	44.3759995	
11	9	10	-86.314773	44.3779984	
12	10	11	-86.307508	44.3681984	
13	11	12	-86.310024	44.3702011	
14	12	13	-86.312541	44.3722	
15	13	14	-86.315057	44.3741989	
16	14	15	-86.317574	44.3762016	
17	15	16	-86.310308	44.3664017	
18	16	17	-86.312825	44.3684006	
19	17	18	-86.315341	44.3703995	
20	18	19	-86.317858	44.3723984	
21	19	20	-86.320375	44.3744011	
22		21	-86.313109	44.3646011	
23	21	22	-86.315625	44.3666	
24	22	23	-86.318142	44.3685989	
25	23	24	-86.320658	44.3706017	
26	24	25	-86.323175	44.3726006	
27					

HOW IS LOCATION REPRESENTED IN DATA

- Another common **Address** format for representing location
- Assumes a street network reference system
- Requires additional processing before it can be mapped or analyzed spatially
- We will learn **Geocoding** in a few weeks

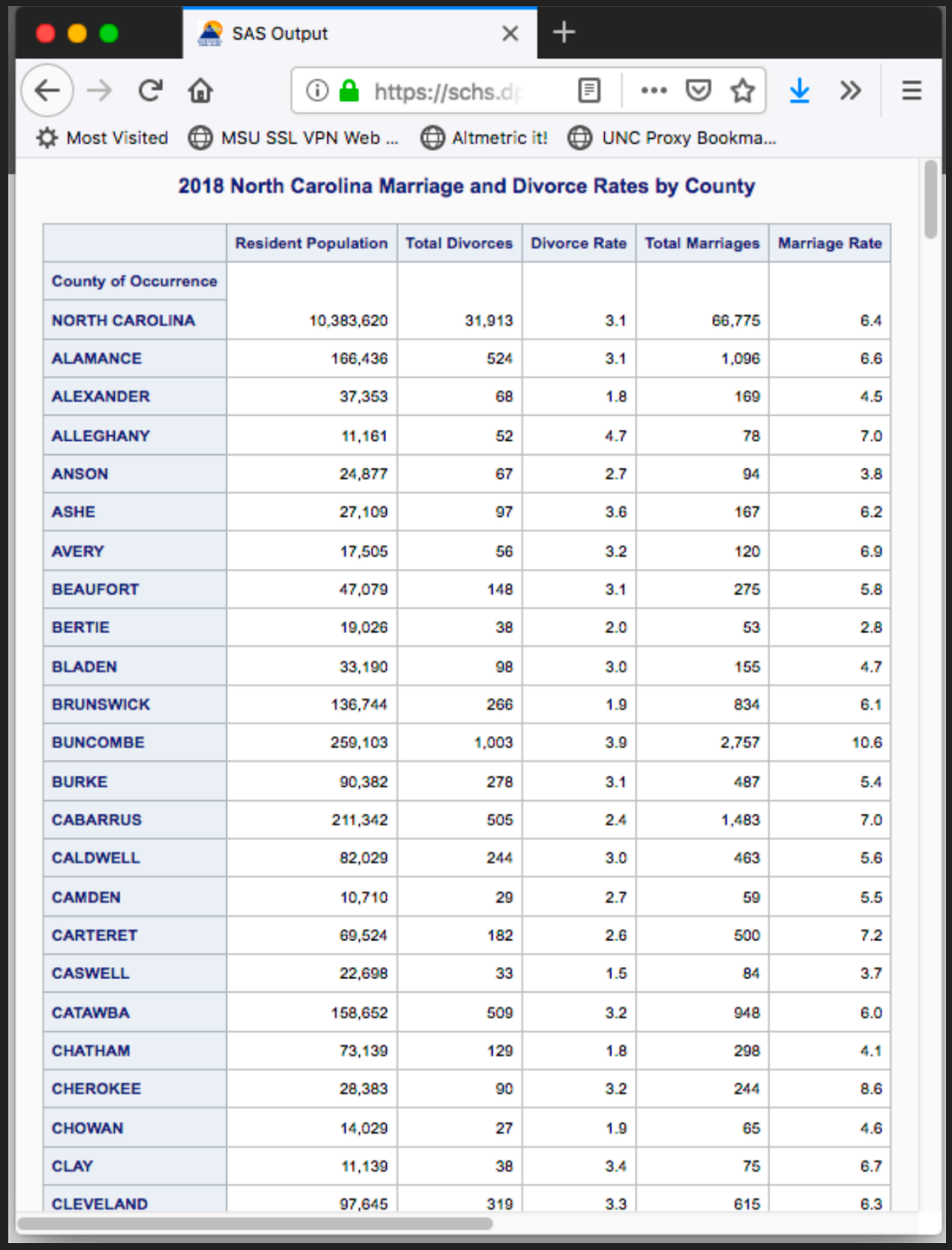


	A	B	C	D	E	F	G	H	I	J	K	L
1	CDSCode	NCESDist	NCESSchool	StatusType	School	StreetAbr	City	Zip	State	OpenDate	ClosedDate	LastUpDate
2	011001700	0691051		Active		313 West Winton Ave.	Hayward	94544-1136	CA			2/2/2017
3	011001701	0691051	10546	Closed	FAME Public Charter	39899 Balentine Dr., Ste. 335	Newark	94560-5359	CA	8/29/2005	7/31/2015	9/1/2015
4	011001701	0691051	10947	Active	Envision Academy for Arts & Technology	1515 Webster St.	Oakland	94612-3355	CA	8/28/2006		7/26/2017
5	011001701	0691051	12844	Active	Community School for Creative Education	2111 International Blvd.	Oakland	94606-4903	CA	8/22/2011		8/16/2017
6	011001701	0691051	12901	Active	Yu Ming Charter	1086 Alcatraz Ave.	Oakland	94608-1265	CA	8/9/2011		5/10/2016
7	011001701	0691051	13008	Active	Urban Montessori Charter	5328 Brann St.	Oakland	94619-3312	CA	8/27/2012		4/10/2018
8	011001701	0691051		Closed	Technical, Agricultural & Nat.	597 C St.	Hayward	94541	CA	7/1/1980	6/30/1989	6/24/1999
9	011001701	0691051	09264	Active	Alameda County Juvenile Hall/Court	2500 Fairmont Ave.	San Leandro	94578-1005	CA	7/1/1980		7/3/2018
10	011001701	0691051	06830	Active	Alameda County Community	313 West Winton Ave.	Hayward	94544-1136	CA	7/1/1980		2/13/2018
11	011001701	0691051	09265	Closed	Alameda County Opportunity	313 West Winton Ave.	Hayward	94544-1136	CA	7/1/1980	6/30/2013	4/28/2014
12	011001701	0691051		Closed	Berkeley Trade & Tech. College					7/1/1980	6/30/1989	6/24/1999
13	011001701	0691051	13887	Active	Oakland Unity Middle	7200 Bancroft Ave. Ste. 261	Oakland	94605-2403	CA	8/23/2015		10/20/2017
14	011001701	0691051		Closed	Canyon Valley Adult School					7/1/1980	6/30/1989	6/24/1999
15	011001701	0691051	14091	Active	Connecting Waters Charter - East Bay	12420 Bentley St.	Waterford	95386-9150	CA	8/16/2017		3/14/2018
16	011001701	0691051	14090	Active	Opportunity Academy	2300 International Blvd.	Oakland	94601-1019	CA	9/5/2017		3/14/2018
17	011001701	0691051		Closed	Roosevelt High (Defunct)					7/1/1980	6/30/1989	6/24/1999
18	011001701	0691051		Active	Aurum Preparatory Academy	1034 66th Ave.	Oakland	94621-3536	CA	8/13/2018		7/30/2018
19	011001701	0691051		Closed	University High School (Defunc					7/1/1980	6/30/1989	6/24/1999
20	011001701	0691051		Closed	Washington Evening High (Defun					7/1/1980	6/30/1989	6/24/1999
21	011001760	0691051	04257	Active	Cox Academy	9860 Sunnyside St.	Oakland	94603-2750	CA	7/1/1980		8/14/2017
22	011001760	0691051	04288	Active	Lazear Charter Academy	824 29th Ave.	Oakland	94601-2205	CA	7/1/1980		8/23/2016
23	011001760	0691051		Closed	Chabot Ranch	2500 Fairmont Dr.	San Leandro	94578	CA	7/1/1980	6/30/1989	6/24/1999
24	011001760	0691051		Merged	Juvenile Court Schools	2400 Fairmont Dr.	San Leandro	94578	CA	7/1/1980	6/22/1987	6/24/1999
25	011001760	0691051		Closed	Las Vistas School	2200 Fairmont Dr.	San Leandro	94578	CA	7/1/1980	6/30/1989	6/24/1999
26	011001760	0691051		Closed	Senior Camp	2600 Fairmont Dr.	San Leandro	94578	CA	7/1/1980	6/30/1989	6/24/1999
27	011001760	0691051		Closed	Snedigar Cottage	2100 Fairmont Dr.	San Leandro	94578	CA	7/1/1980	6/30/1989	6/24/1999
28	011001760	0691051		Merged	Koster/Whiteford Special Center	35725 Cedar Ave.	Newark	94560	CA	7/1/1980	6/22/1987	6/24/1999
29	011001760	0691051		Closed	Whiteford School (TMR)	685 A St.	Hayward	94541	CA	7/1/1980	6/30/1989	6/24/1999
30	011001760	0691051		Closed	Alameda County Special Education	685 A St.	Hayward	94541	CA	7/1/1980	7/24/1984	6/24/1999
31	011001760	0691051		Closed	Buena Vista School (Girls)	2200 Fairmont Dr.	San Leandro	94578	CA	7/1/1980	6/30/1989	6/24/1999
32	011001760	0691051		Merged	Whiteford (June) School	35725 Cedar Blvd.	Newark	94560	CA	7/1/1980	6/30/1989	6/24/1999
33	011001760	0691051		Merged	School for School-Age Mothers	8151 Village Pkwy.	Dublin	94568	CA	7/1/1980	6/30/1989	6/24/1999
34	011001760	0691051		Closed	Sequoia Deaf/Blind Program	685 A St.	Hayward	94541	CA	7/1/1980	7/24/1984	6/24/1999
35	011001760	0691051		Merged	Burke (William P.) Special Center	612 West A St.	Hayward	94541	CA	7/1/1980	6/22/1987	6/24/1999
36	011001760	0691051		Closed	East County Dch	7997 Vomac Rd.	Dublin	94566	CA	7/1/1980	6/30/1989	6/24/1999
37	011001760	0691051		Merged	La Fleche (Rock) Special Center	6925 Chabot Rd.	Oakland	94618	CA	7/1/1980	6/22/1987	6/24/1999
38	011001760	0691051		Merged	Motta (Ronald) Special Center	40950 Chapel Way	Fremont	94538	CA	7/1/1980	6/22/1987	6/24/1999
39	011001761	0691051	08672	Active	Alameda County Special Education	313 West Winton Ave.	Hayward	94544-1136	CA	7/1/1980		10/13/2015
40	013160900	0600002		Active		500 Walnut Ave.	Fremont	94536-4365	CA			11/20/2017
41	013160901	0600002	10346	Active	California School for the Blind	500 Walnut Ave.	Fremont	94536-4365	CA	7/1/1980		11/10/2016
42	013161700	0600003		Active		39350 Gallaudet Dr.	Fremont	94538-2308	CA			7/27/2017
43	013161701	0600003	10347	Active	California School for the Deaf-Fremont	39350 Gallaudet Dr.	Fremont	94538-2308	CA	7/1/1980		6/27/2017
44	014040272	0601397		Closed	David W. Gordon Govt. Affairs	PO Box 944272	Sacramento	94244	CA	7/1/1980	6/30/1989	6/24/1999

HOW IS LOCATION REPRESENTED IN DATA

PLACE NAME

- Another common format for representing location
- Assumes a defined (or definable) geographic location or region
- Requires additional processing before it can be mapped or analyzed spatially



2018 North Carolina Marriage and Divorce Rates by County

County of Occurrence	Resident Population	Total Divorces	Divorce Rate	Total Marriages	Marriage Rate
NORTH CAROLINA	10,383,620	31,913	3.1	66,775	6.4
ALAMANCE	166,436	524	3.1	1,096	6.6
ALEXANDER	37,353	68	1.8	169	4.5
ALLEGHANY	11,161	52	4.7	78	7.0
ANSON	24,877	67	2.7	94	3.8
ASHE	27,109	97	3.6	167	6.2
AVERY	17,505	56	3.2	120	6.9
BEAUFORT	47,079	148	3.1	275	5.8
BERTIE	19,026	38	2.0	53	2.8
BLADEN	33,190	98	3.0	155	4.7
BRUNSWICK	136,744	266	1.9	834	6.1
BUNCOMBE	259,103	1,003	3.9	2,757	10.6
BURKE	90,382	278	3.1	487	5.4
CABARRUS	211,342	505	2.4	1,483	7.0
CALDWELL	82,029	244	3.0	463	5.6
CAMDEN	10,710	29	2.7	59	5.5
CARTERET	69,524	182	2.6	500	7.2
CASWELL	22,698	33	1.5	84	3.7
CATAWBA	158,652	509	3.2	948	6.0
CHATHAM	73,139	129	1.8	298	4.1
CHEROKEE	28,383	90	3.2	244	8.6
CHOWAN	14,029	27	1.9	65	4.6
CLAY	11,139	38	3.4	75	6.7
CLEVELAND	97,645	319	3.3	615	6.3

SPATIAL DATA TYPES

ABSTRACTION

- The Earth is infinitely complex and also infinitely large
- Far too much information to model the world perfectly (exter and detail)
- Simplification is necessary
- This process is known as **abstraction**
  - Some information must be ignored or aggregated
  - Relative process

LEVELS OF ABSTRACTION

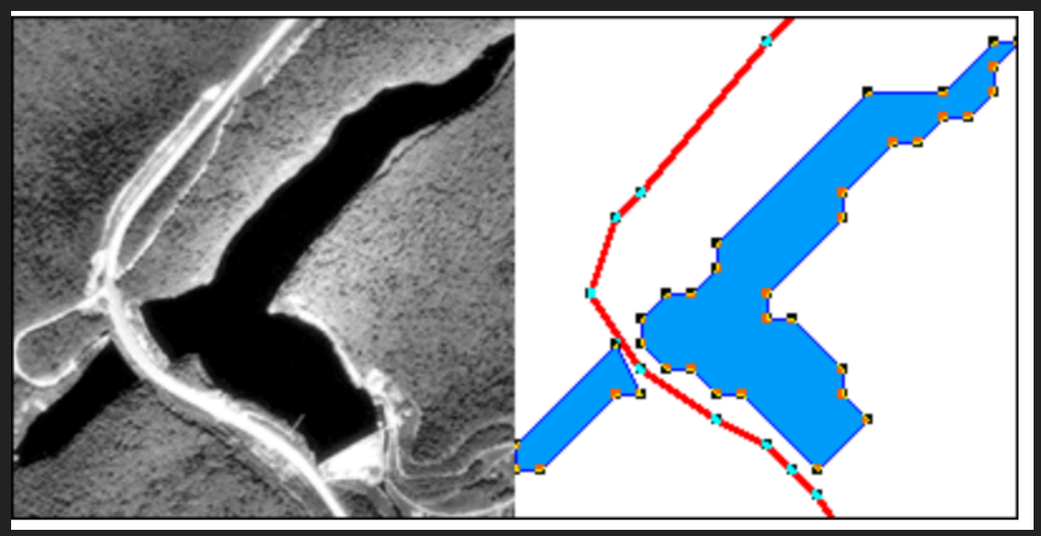
- **Real World**
  - The world as it is, in all its complexity
- **Data Model**
  - This stems from our conceptual view of the world
  - The world of things noticed and named (ontology, semantics)
    - Some things are more “solid” than others
    - Physical features, e.g., buildings, rivers, forests
    - Is there such a thing as a habitat type or an ethnic group? How is it to be defined and represented?

LEVELS OF ABSTRACTION

- **Data Structure**
  - Formal symbolic representation of specific things in the data model
  - Organized set of files for managing defined entities in the data model (formalized in the data structure)
- **File Structure**
- Computer representation of files

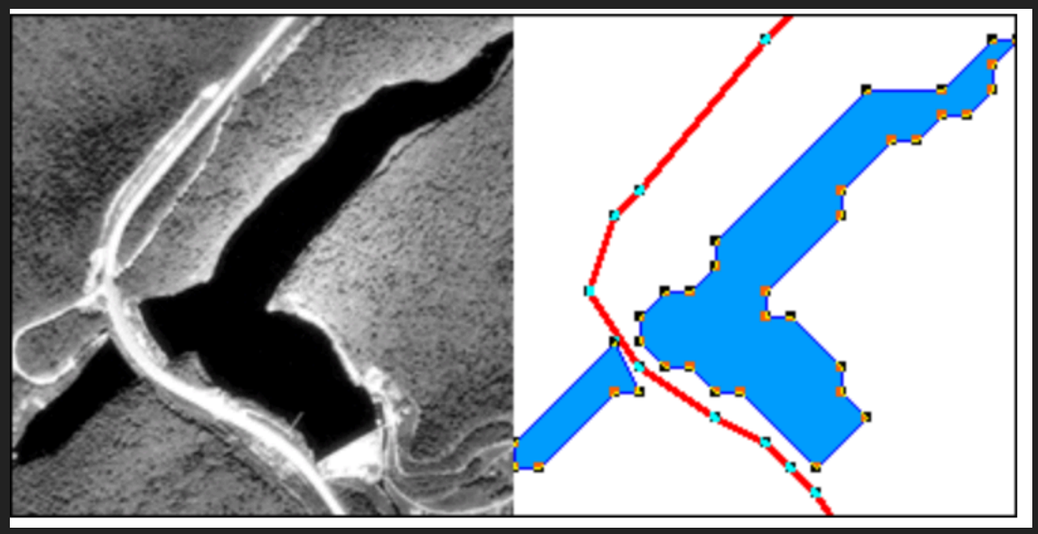
OBJECTS

- Present a view of the world in which the Earth surface is populated by a number discrete entities (e.g., houses, streets, lakes)
  - Objects can be 0-, 1-, 2-, or 3-dimensional
- Object types include points, lines, polygons, networks



FIELDS

- Fields present a view of the world in which Earth is a continuous surface that is characterized by a number of properties
- e.g., temperature, land use, soil pH

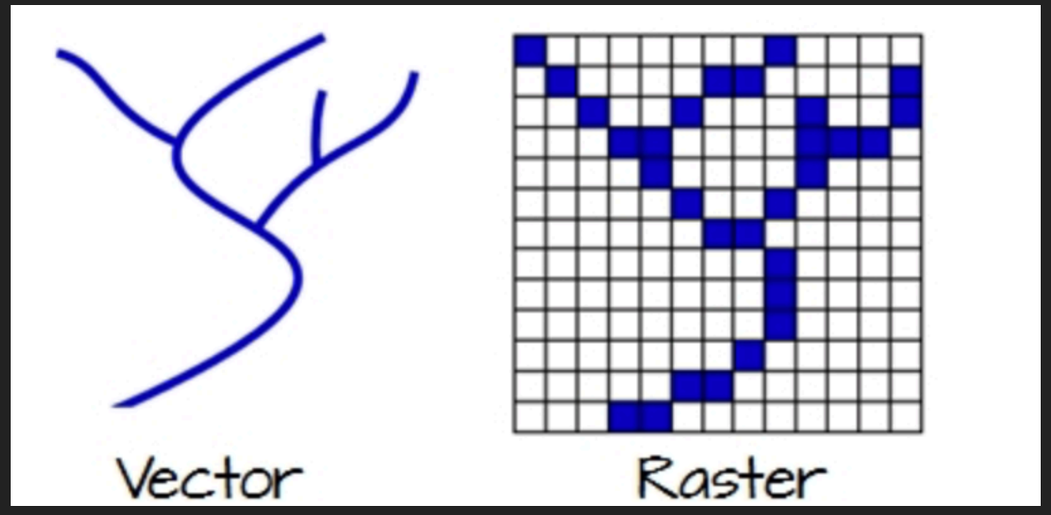


OBJECTS VS FIELDS: CONCEPTUAL DIFFERENCES

- **Observed element**
  - In the object model, focus is on the “object”
    - Object may have multiple attributes
  - In the field model, focus is on the “attribute”
    - Attribute varies over space
- **Empty space**
  - In the object model, space between entities is “empty”
  - No empty space in the field model

SPATIAL DATA MODELS

- Describe the conceptual models for digital representation
  - Two primary models are **raster** and **vector**
- **Raster**
  - Uses grid cells
  - Each cell coded with a single value
- **Vector**
  - Uses spatial “features”
  - Points, lines, polygons



QUESTIONS ?