2

REPRESENTATIONS OF EARTH

Chapter Outline

MAPS AND LOCATION ON EARTH
- Earth's Shape and Size
- Globes and Great Circles
- Latitude and Longitude

THE GEOGRAPHIC GRID
- Parallels and Meridians
- Longitude and Time
- The International Date Line
- The U.S. Public Lands Survey System
- The Global Positioning System

MAPS AND MAP PROJECTIONS
- Advantages of Maps
- Limitations of Maps
- Examples of Map Projections
- Properties of Map Projections
- Map Basics
- Thematic Maps
- Topographic Maps

MODERN MAPMAKING
- Geographic Information Systems

REMOTE SENSING OF THE ENVIRONMENT
- Digital Imaging and Photography
- Specialized Remote Sensing Techniques
- Multispectral Remote Sensing

Learning Objectives

- Explain the ways that Earth and its regions, places, and location can be represented on a variety of visual media: maps, aerial photographs, and other imagery.
- Assess the nature and importance of maps and maplike presentations of the planet or parts of Earth, citing some examples.
- Find and describe the locations of places using coordinate systems, use topographic maps to find elevations, and understand the three types of map

scales.

- Demonstrate knowledge of techniques that support geographic investigations, including mapping, spatial analysis, satellite and aerial photography.
- Evaluate the advantages and limitations of different kinds of representations of Earth and its areas.
- Understand how the proper techniques, images, and maps can be used to best advantage in solving geographic problems.
- Recognize the benefits of spatial technologies such as geographic information systems (GIS), the Global Positioning System (GPS), and remote sensing.

Key Terms and Concepts

cartography
oblate spheroid
great circle
hemisphere
small circle
coordinate system
North Pole
South Pole
equator
latitude
prime meridian
longitude
geographic grid
parallel
meridian
time zone
solar noon
International Date Line
U.S. Public Lands Survey System
township
section
global positioning system (GPS)
map projection
conformal map
Mercator projection
equal-area map
equidistance
azimuthal map
compromise projection
legend
scale
verbal scale
representative fraction (RF scale)
graphic (bar) scale
magnetic declination
thematic map
discrete data
continuous data
isoline
topographic contour line
contour interval
profile
gradient
digital elevation model (DEM)
vertical exaggeration
geographic information system (GIS)
visualization models
remote sensing
aerial photograph
digital image
pixel
resolution (spatial resolution)
near-infrared (NIR)
thermal infrared (TIR)
radar
weather radar
sonar
multispectral remote sensing

Lecture Outline

I. **Chapter Preview**

II. **Maps and Location on Earth**

- A. Earth's Shape and Size
- B. Globes and Great Circles
- C. Latitude and Longitude
  - 1. Measuring Latitude
  - 2. Measuring Longitude
  - 3. Decimal Degrees

III. **The Geographic Grid**

- A. Parallels and Meridians
- B. Longitude and Time
- C. The International Date Line
- D. The U.S. Public Lands Survey System
- E. The Global Positioning System

IV. **Maps and Map Projections**

- A. Advantages of Maps
- B. Limitations of Maps
- C. Examples of Map Projections
- D. Properties of Map Projections
  - 1. Area
  - 2. Shape
  - 3. Distance
  - 4. Direction
  - 5. Compromise Projections
- E. Map Basics
  - 1. Legend
  - 2. Scale
  - 3. Direction
- F. Thematic Maps
- G. Topographic Maps

V. **Modern Mapmaking**

- A. Geographic Information Systems
  - 1. What a GIS Does

VI. **Remote Sensing of the Environment**

- A. Digital Imaging and Photography
- B. Specialized Remote Sensing Techniques
  - 1. Radar, Lidar, and Sonar

C. Multispectral Remote Sensing

Summary

- Maps, globes, and other graphic images of the Earth are important tools for geographic analysis, and each type of tool has specific advantages and limitations.
- The location of a place or area can be described by an absolute location that uses a grid system of coordinates, or by relative location in terms of a well-known nearby feature.
- Longitude (E-W) and latitude (N-S) is a commonly used coordinate system for locating points on Earth's surface.
- In the Midwestern and Western United States, the Township and range system is widely used to locate areas and plots of land.
- Physical geographers use many different digital and satellite-based technologies to study key locations, processes, features, and environmental changes.
- A geographic information system (GIS) is a powerful technology that integrates data, maps, information, and imagery for spatial analysis.

Teaching Tips – Online Resources

Websites

Time Zones
An interactive site with time maps, a world clock with a variety of parameters, a sun clock, world news, and frequently asked questions.
http://www.worldtimezone.com/

The Big Map Blog
A collection of unique and historical map images with zooming capabilities.
http://www.bigmapblog.com/

Google Earth / Google Maps
These free tools are essentially GISs!
http://www.google.com/earth/index.html
https://maps.google.com/

Videos

LIDAR
See how lidar works.
http://www.youtube.com/watch?v=WJoaksSKaOo

Answers to Questions for Review

1. A great circle marks the shortest distance between two points on a sphere (Earth). [p. 24]

2. By the late 1800s, the specific nature of "local time", which constantly changes throughout the day as well as with any east-west travel regardless of distance, had become unacceptable in both transportation and communication. To resolve the problem, 24 hourly time zones, 15 degrees in longitude, were created. Because the prime meridian at Greenwich (0 degrees longitude) was selected as the central meridian of the initial time zone, all subsequent time zones were centered on meridians in multiples of 15 degrees east and west of the prime meridian. [p. 25]

3. You will "lose" a day. This means you will change the date to the next day. [p. 26]

4. Longitude and latitude coordinates describe specific locations on the entire geographic grid, whereas the U.S. Public Lands Survey System was designed to locate parcels of land in the United States west of Pennsylvania. [p. 28]

5. It is impossible to accurately depict a sphere or large parts of a sphere on flat paper without distortion. A conformal map shows correct comparative shapes of mapped areas, and an equal-area map shows correct comparable areas of mapped regions (areas). [p. 31]

6. An RF scale is a fraction or proportion of one unit of map distance to the number of the same units that it represents on the map (1:24, 000). A verbal map scale is a written statement of the map's scale, such as one-inch equals 2,000 feet. This is the same as 1:24,000, but in a verbal scale, it is acceptable to mix units. [p. 34]

7. Thematic map layers are digitally stored maps of individual features (roads, terrain, climate, vegetation patterns, rivers, lakes, etc.) that can be computer accessed and displayed in any desired combination for geographic analysis. The finished map will combine whatever layers are needed for a particular study. [pp. 35,36]

8. Before computers, maps had to be drawn individually and redrawn or modified by hand if they required updating of the mapped information. Computers allow easy map drawing and revision, and overlaying of mapped data and information. [p. 37]

9. A photograph is taken with a camera and film, a digital image is a visual mosaic, photo-electronically captured and stored for direct input into a computer. [p. 40]

10. Weather radar images show us patterns of precipitation that would otherwise be hidden by cloud cover. [p. 42]

Answers to Practical Applications

M.A. = many answers are possible

1. Topographic maps show actual elevations with numbers. The highway map and satellite image do not. All three provide general impressions of the geography of the area in question, and all three would show major roads. [Topographic maps: pp. 36-37; Satellite images: pp. 41-43].

2. M. A. The answer will vary greatly among students. Some important layers would be roads, campsite locations, slope, geology, vegetation, location of natural resources, soils, elevations, locations of wildlife sightings, water bodies, and other park amenities. [pp. 37, 38]

3. If it is Tuesday, 2 A.M. in New York (75° W time zone—EST), it is three hours earlier in <u>California</u> (120° W time zone—PST), which would be <u>11 P.M. on Monday night</u>, (three hours earlier for every 15° west and later for every 15° east). [p. 27]

   London is in the 0° time zone (GMT), and 75° east of New York, so it is five hours later than New York (75/15 = 6), or <u>7 A.M. in London on Tuesday</u>. [p. 27]

   Sydney is in the 150 degrees E time zone, east of London, so the time is 10 hours later or <u>5 P.M. Tuesday in Sydney, Australia</u>. [p. 27]

4. Students should use the formula: map distance/Earth distance = 1/ Representative Fraction Denominator. 10cm = 1km, change to meters: 0.10m = 1000m, so — 0.10m/1000m = 1/RDF or 1/10,000. In feet/inches: 3.94 in = 3281.12 ft—so change to same units 3.94 in = 39,372 inches (12 inches x 3281.12). So — 3.94/39,372 = 1/RFD, and RFD = 9993 or an RF scale of 1/10,000 if rounded off. **Important:** the units in an RF cancel out, so an RF scale is a dimensionless number. [p. 34]

5. Using the Search window in Google Earth, fly to the heart of the following cities and identify the latitude and longitude. Measure the latitude and longitude using decimal degrees with two decimal places (e.g., 41.89 N as opposed to 41°88'54" N). Make sure that you correctly note whether the latitude is North (N) or South (S) of the equator and whether the longitude is East (E) or West (W) of the prime meridian.

a. London, England:	51.05N, 0.13W
b. Paris, France:	48.85N, 2.35E
c. New York City:	40.71N, 74.00W
d. San Francisco, California:	37.77N, 122.42W
e. Buenos Aires, Argentina:	34.61S, 58.37W
f. Cape Town, South Africa:	33.92S, 18.42E
g. Moscow, Russia:	55.75N, 37.62E
h. Beijing, China:	39.90N, 116.40E
i. Sydney, Australia:	33.86S, 151.20E
j. Your hometown:	M.A.

Enter the following coordinates into Google Earth to identify the locations. Go to the Google Earth preferences and select decimal degrees. Review: Latitude is always listed first, and if there are no N, S, E, W, designations, positive numbers mean N or E and negative numbers mean S or W.

a. 41.89N, 12.492E:	Roman Coliseum, Rome, Italy
b. 33.857S, 151.215E:	Opera House, Sydney, Australia
c. 29.975N, 31.135E:	Pyramids, Giza, Egypt
d. 90.0, 0:	South Pole
e. -90.0, -90.0:	South Pole
f. 27.175, 78.042:	Taj Mahal, India
g. 27.99 N, 86.92E:	Mt. Everest, Nepal
h. 40.822N, 14.425E:	Mt. Vesuvius, Italy
i. 48.858N, 2.295E:	Eiffel Tower, Paris, France

Answers to Figure-Legend Questions

M.A. = Many answers possible

Figure 2.1 These hand-drawn depictions of the landscape are valuable, and very good at emphasizing the topographic features and giving a good impression of the lay of the land. [p. 23]

Figure 2.2 Earth's shape is very close to being a perfect sphere, so its deviations from sphericity cannot be seen when viewing the planet from space. [p. 23]

Figure 2.4 Mansfield is at C-6. F-3 is the location of Cleveland. [p. 24]

Figure 2.5 90° N latitude. Note: the North and South poles do not require a longitudinal position. [p. 24]

Figure 2.6 Meridians converge; parallels do not. All meridians are half great circles; all parallels are small circles except the equator. Meridians are true north-south running lines; parallels are true east-west running lines. [p. 26]

Figure 2.7 The International Date Line has been jogged around a few locations to ensure that countries, cities, towns, or island groups do not have different days within their borders. [p. 28]

Figure 2.8 SE l/4 of the SE 1/4, Sec. 20, T3S, R2E. [p. 28]

Figure 2.9 Mountain ranges of this magnitude do not exist in the Midwest. [p. 29]

Figure 2.11 The use of GPS technology is becoming commonplace. A GPS unit can broadcast its position (e.g., placed in cars for location in theft recovery), and they are useful for wilderness hikers to find their positions relative to a map. Emergency vehicles have GPS units, so that a 911 operator can tell where the nearest emergency vehicle is to a place of need, or how to find a location—and thus allows faster response times. [p. 30]

Figure 2.13 The moon has been mapped using satellite observations of the terrain on all sides of our lunar neighbor. [p. 31]

Figure 2.14 We use different map projections for many reasons; sometimes a certain projection fits the shape and latitudinal area of the area we wish to present on the map. Other times we may wish to preserve a particular map property, such as shape, distance (area), or direction. [p. 31]

Figure 2.15 The distortion is very great in regions away from the Equator. Greenland appears larger than South America on a Mercator projection when in fact it is only about 1/8th the area of South America. [p. 32]

Figure 2.16 The answer depends on the intended use of the map. If it is important to compare areas of regions, countries, continents, or other areas, preserving area is best. If it is important to show the accurate shape of the same kinds of areas, than preserving shape is more important. No map of a large area can do both [p. 32]

Figure 2.18 On these compromise maps, the continents are shown with reasonably good shape preservation and reasonably good size proportion. In the interrupted map (b) the distortion is shifted to the oceans — this map would not be useful for sea navigation. [p. 33]

Figure 2.20 Navigating with (or using) a magnetic compass, it is important to know the magnetic declination of our location because the compass must be adjusted for the local declination in order to get a reading corrected to true north. Otherwise, we would not really know which direction we are heading, without correcting the compass reading for declination. [p. 35]

Figure 2.21 M.A. Examples: discrete occurring only at specific locations — mountain peaks (point), thunderstorm cells (area), coastline (line), and continuous means any variable that has a measurable variable everywhere (air pressure, vegetation cover density). [p. 35]

Figure 2.22 Students should be able to get a general impression of the landscape by examining the topographic contour lines, particularly their shape and spacing. [p. 36]

Figure 2.23 Close spacing of contours means steep terrain and wide spacing means a more gentle or perhaps nearly flat slope. [p. 36]

Figure 2.24 A Geographic Information System (GIS) has almost unlimited uses in addition to those concerned with the environment — any situation that requires spatial information combined in layers can benefit from a GIS. This includes allocation of emergency response systems, finding the best (or worst — places to definitely avoid) locations for an economic, recreational, or agricultural activity — in other words, virtually any kind of activity. [p. 37]

Figure 2.26 The high potential earthquake hazard for the East Coast and the Midwest area near St. Louis, Missouri, and also earthquake hazard in New England. [p. 40]

Figure 2.28 Oblique views have a more natural scene to a normal human visual perspective. Vertical views are more map-like. [p. 41]

Figure 2.29 Near-infrared (b). Near-infrared images show a stronger contrast between water (dark blue) and the red growing vegetation; so it is much easier to see the boundary between land and water (important for making maps of the location). Crops and other vegetation types can also be discriminated better on the color infrared photograph than on the normal color print. [p. 41]

Figure 2.30 It is important to know where storms are located and what areas they are moving toward, as well as how fast they are moving. [p. 43]

Figure 2.32 Weather radar produces a display that is much like a map of precipitation patterns — where rain, snow, or hail are falling and in what intensity. Imaging radar makes an image of the land surface — slopes, hills, valleys, plains, and mountains. [p. 43]

Answers to Understanding Map Content 2.1

M.A. = Many answers possible

M.A. Students should be able to demonstrate that political, continental, and major geographical (e.g., significant mountain ranges) boundaries have an effect on time zone placement.

Answers to Map Interpretation: Topographic Maps

1. One inch represents 12,000 inches on the Earth's surface. The contour interval is 10 feet.
2. The highest elevation is 5350 feet, located just to the north of the crater. The lowest elevation is 4800 feet, located on the Snake River. The depth of the crater is approximately 350 feet.
3. The slope ratio is approximately 1:3.5.
4. Having both a topographic map and an aerial photograph lets you see the big picture. Topographic maps show greater topographic detail and let you make calculations. Aerial photographs show land use and color. The magnetic declination on the map is 17 degrees.