Isn't That Spatial: Teaching Coordinate Systems Using Topographic Maps

--Joseph J. Kerski

In my last column, I explored how to integrate geography, mathematics, fieldwork, and GPS by teaching about coordinate systems and map projections. In this column, my goal is to provide information about an excellent way to teach these concepts and others using familiar objects—USGS topographic maps.

USGS topographic maps at 1:24,000 scale contain information about three different coordinate systems—latitude/longitude (geographic), Universal Transverse Mercator (UTM), and State Plane. Refer to the topographic map figure in this article to understand what the numbers in the map margins are, and how to use them in the classroom.

1 State plane coordinate system -- 660,000 feet north from origin within the state plane grid system.

   This coordinate system was established by the U.S. Coast and Geodetic Survey for use in defining positions of points in terms of plane rectangular (x, y) coordinates. There is usually at least one system for each state with a specific origin point. Each state determines whether the units will be measured in feet or meters.

2 Latitude. Here, 39 degrees, 37 minutes, 30 seconds (North Latitude; north of the Equator, which is 0 degrees latitude). This number is in degrees-minutes-seconds (DMS) format. Have students convert these to decimal minutes (DM) format. For example, 30 seconds / 60 seconds = .5 minutes. Therefore, the DM format for this latitude is 39 degrees 37.5 minutes. Next, have students convert DMS to Decimal Degree (DD) format: 30 seconds / 3600 = .008333 degrees. 37 minutes / 60 = .61666 degrees. Add them together (.008333 + .61666 + 39) for a DD reading of 39.625 degrees. Use a GPS unit and try all three formats there as well.

3 Longitude. Here, 105 degrees, 15 minutes, 00 seconds (West Longitude; west of the Prime Meridian of Greenwich, which is at 0 degrees longitude). Convert these DMS longitude values to Decimal Minutes and Decimal Degrees values as you did for latitude.

4 North American Datum of 1927. This is the horizontal datum; the reference for all x-y coordinates. If you are using GPS along with a topographic map, you need to make sure that the GPS datum matches the datum used on the map. Note that the North American Datum of 1983 is also shown on this map by the dashed corner ticks about 60 meters east of the southwest corner of the map.

   This block of text also identifies the correct Universal Transverse Mercator (UTM) zone. These are the 6-degree-wide zones that I described in my previous column. This map lies in Zone 13, which spans 102 to 108 degrees West Longitude.

   This block also identifies the state plane coordinate system used on the map; here, Colorado Coordinate System, Central Zone. You could create a grid across the map by connecting all of the 10,000-foot margin ticks. How much land is covered by the resulting rectangles that are 10,000 feet x 10,000 feet?

5 GN. This is UTM grid north; measured at the center of the map.

6 State plane coordinate system coordinate. This tick mark is 2,080,000 feet east of the origin of the Colorado Central Zone.

7 ★ This star indicates true or geographic north. This star and line points to the north geographic pole.

8 MN. Magnetic north. This is the approximate direction (at the center of the map) to the north magnetic pole at the date given, in this case 1994. Remember that the magnetic pole and thus the declination changes over time. This is the direction to which a magnetic compass needle points. Go outside and bring the topographic map and use it with a standard compass or with a GPS unit with a compass.

9 11^{o} east. This is the magnetic declination or variation of the compass -- the number of degrees a compass needle at a particular location bears away from true north and points to the north magnetic pole. 196 MILS indicates the military angular measurement of the angle.

10 Longitude. This is a 2.5 minute geographic grid tick – 105 degrees (understood), 12 minutes, 30 seconds west. Have students connect the 2.5-minute grid ticks in the margin with lines across the map. This will divide the map into 9 rectangles of 2.5 minutes x 2.5 minutes. These lines will go through the 2.5-minute grid crosses in the middle of the map. Doing this provides a handy 9-section map that you can use for directing student attention toward features you want them to identify. Ask the students why the rectangles are not perfect squares. It is because of the convergence of longitude lines toward the poles. Get out a topographic map of a place north or south of the current map. Will the 2.5-minute rectangles be more like squares closer to the pole or closer to the equator. Why?

11 Adjoining USGS quadrangle name "Indian Hills." The notation "4963 II SW" is the NGA (National Geospatial-Intelligence Agency, the Department of Defense mapping agency) sheet designator for the same map.

Under this text is the scale. Use it to measure distances and create topographic profiles. Compare this 1:24,000-scale map to a USGS map of the same area at 1:100,000 scale, 1:250,000 scale, and 1:500,000 scale. How much area does each map cover? What detail is visible on each map?

Under the scale bar is the contour interval; the vertical distance between each contour line. Compare this contour interval to one in a flatter or steeper area on a different map. How are contour intervals chosen? This block also indicates the vertical datum used to reference the vertical distances.

12 Range 69 West. This is part of the Township and Range System. This is the 69^{th} range west of 6th Principal Meridian (which is at Meades Ranch, Kansas). Each range is 6 miles wide, and therefore, the origin is 69 x 6 = 414 miles to the east.

In 1785, Congress adopted a plan for surveying public lands. According to this plan, land was divided into townships approximately 6 miles square, which were further subdivided into 36 sections approximately 1 mile square. Each section was divided into smaller plots, for example, of 640 acres. Principal meridians and base lines were established as a reference system for the township surveys.

Pull up some online legal descriptions or lots for sale, and note how the Public Land Survey System pervades modern law. It is yet another way to "reference," or "address" locations on the Earth's surface.

13 UTM (Universal Transverse Mercator) easting value. Here, the point is 486,000 meters false easting (last 3 zeroes are omitted for brevity) (Zone13). The Central Meridian in Zone 13 is at 500,000 meters easting, which is 14,000 meters, or 14 kilometers, to the east of this line (in downtown Denver, actually). Change the units of your GPS to UTM and have students walk directly east. The eastings should increase by 1 meter with each step they take. Then, walk north and watch the distance to the equator increase. Meters are an easier unit to work with than the fractions of a degree with latitude-longitude, and therefore, UTM is quite useful and logical to use in the classroom. In addition, a meter is the same everywhere across the Earth's surface, unlike a degree, which changes depending on where a person is on the planet.

14 UTM easting value. This line is 488,000 meters false easting (Zone 13). Have the students draw the 1000-meter grid lines across the map using the UTM coordinates in the margins. Each resulting grid section will be 1000 meters x 1000 meters or 1 square kilometer.

15 Map Name. Maps are usually named after the most prominent cultural (airport, town) or physical (mountain, valley, lake) feature on the map. What is considered most prominent may have changed since the map was created. For example, Eastlake, Colorado was named after a railroad siding, but the map is now nearly covered by the suburb of Thornton. Discuss with your students the types of changes that can occur to make the original map name obsolete. If you were to name this section of the Earth, what would you name it?

This block also contains the Map reference code:
39 = Degrees North Latitude
105 = Degrees west longitude
F2 = index number (area reference code)
TF = <u>T</u>opographic map with contour values in <u>F</u>eet
024 = 1:24,000 scale

This block also contains the date of the map, and also any revision dates. What has changed since the map was made? What was added when the map was revised? What has stayed the same? Some maps contain purple revisions to help identify the changes. In other cases, you may have to search for the older edition using resources I have identified in a previous column.

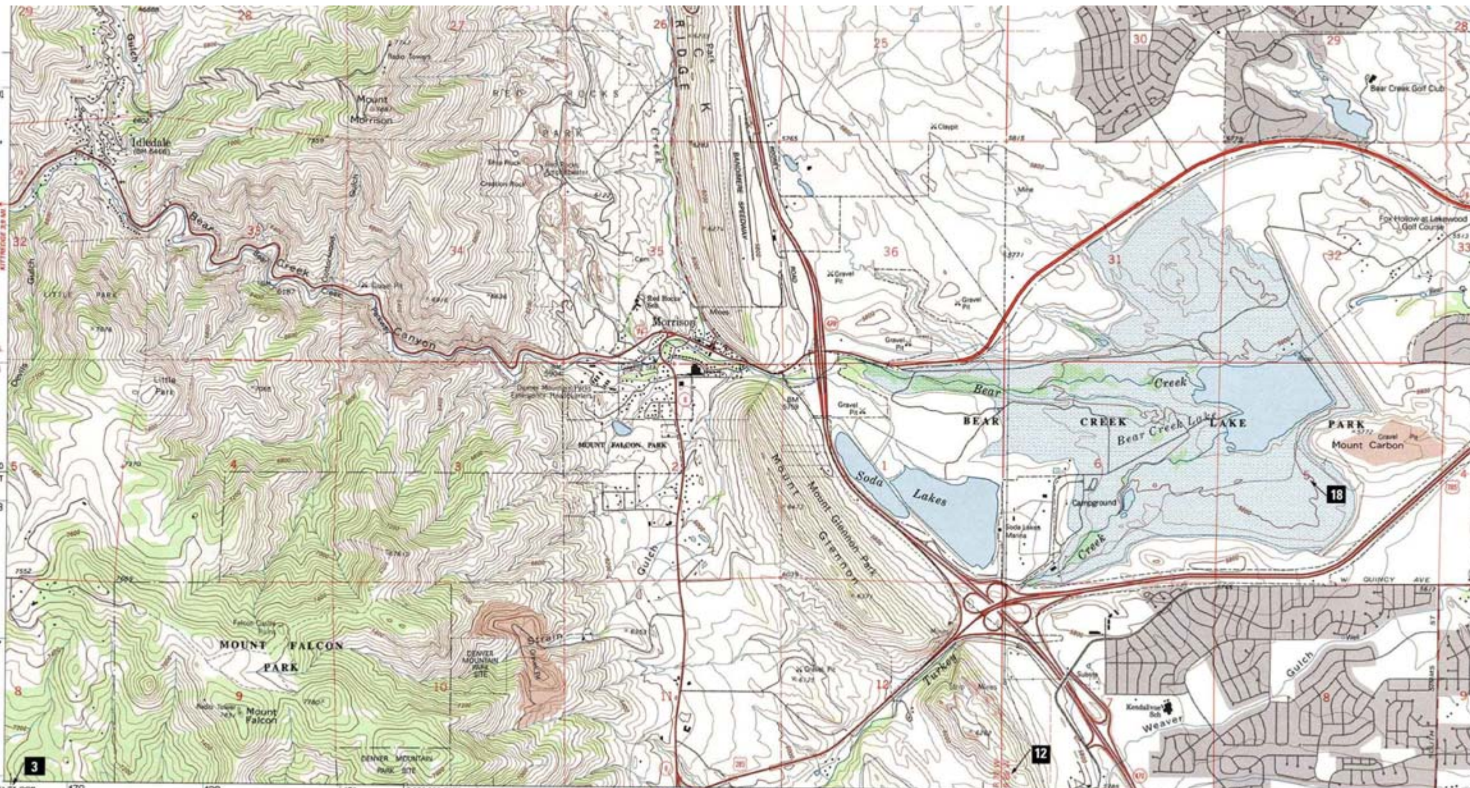
16 ISBN number – International Standard Book Number.

17 UTM northing value. Here, this line is 4,387,000 meters north from the Equator. "Nothings" in the southern hemisphere begin with the Equator value = 10,000,000 meters and decrease in value as one moves toward the South Pole.

18 Section number 5. A part of the Public Land Subdivisions; each section is 1 square mile. Have students note how corrections were made on maps in the original survey, where the section lines deviate from being east-west and north-south. Which section on the map would you say has the greatest population density? Why?

19 Township 4 South in the Public Land Survey System. This township is 4 townships (or 4 x 6 = 24 miles) south of the base line. In this part of the country, the Base Line of 1855 is used; the base line is on 40 degrees north latitude.

20 Latitude reading. This is another 2.5 minute grid tick; here, 39 degrees (understood), 40 minutes, 00 seconds.



39°37′30″ 105°15′00″ 479 480 481 2 080 000 FEET 12′30″ 483 (INDIAN HILLS) 4963 II SW 485 10′00″ 486 487 488000mE 105°07′30″ 39°37′30″

40°00″ 4391 660 000 FEET 4388 4387 4387000mN

(CONIFER) 4963 III SE

(LITTLETON) 4963 II SE

Produced by the United States Geological Survey

Control by USGS and NOS/NOAA

Compiled from aerial photographs taken 1954 and 1955. Field checked 1965
Revised from aerial photographs taken 1988 and 1990 and other sources
Map edited 1994. Contours and land elevations have not been revised and may conflict with other content

North American Datum of 1927 (NAD 27). Projection and blue 1000-meter Universal Transverse Mercator ticks, zone 13
10 000-foot ticks: Colorado Coordinate System, central zone

North American Datum of 1983 (NAD 83) is shown by dashed corner ticks. The values of the shift between NAD 27 and NAD 83 for 7.5-minute intersections are obtainable from National Geodetic Survey NADCON software

Areas covered by dashed light-blue pattern are subject to controlled inundation to 5667 feet

Gray tint indicates areas in which only landmark buildings are shown

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

GN MN 0°07′ 2 MILS 11° 196 MILS

UTM GRID AND 1994 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 KILOMETER

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

COLORADO

QUADRANGLE LOCATION

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1994

ROAD CLASSIFICATION

Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U. S. Route
State Route

MORRISON, CO
39105-F2-TF-024

1965
REVISED 1994
DMA 4963 II NW-SERIES V877

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20