Untangling Longitude and Latitude

Because of the Earth's shape, the same distance may correspond to different changes in longitude and latitude in different locations. To make any sense out of geographic coordinates, it is important to know how many meters or feet represent one degree (minute, second) of longitude and latitude for a given set of data points.

Helper's Guide

Answers to Learning by Doing exercises

1.

Point No.	Longitude, °	Latitude, °	F_{lon}	F_{lat}
1	86.67	40.00	84135 m/°	111054 m/°
2	15.36	62.00	171909 ft/°	365636 ft/°
3	36.24	25.39	100.9 km/°	110.8 km/°
4	128.45	44.75	49.0 mile/°	69.0 mile/°

Make sure students use proper unit conversions to complete this exercise.

2.

	Longitude	Latitude
0.000001° (degrees)	= 0.084 m = 0.276 ft	= 0.111 m = 0.364 ft
0.00001° (degrees)	= 0.84 m = 2.76 ft	= 1.11 m = 3.64 ft
0.001' (minutes)	= 1.40 m = 4.59 ft	= 1.85 m = 6.07 ft
0.1" (seconds)	= 2.34 m = 7.68 ft	= 3.09 m = 10.12 ft

Exact calculations

Proper formulas to determine F_{lon} and F_{lat} are:

$$F_{lon} = \frac{\pi}{180^\circ}\left(\frac{a^2}{\sqrt{a^2\cos^2\varphi + b^2\sin^2\varphi}} + h\right)\cos\varphi$$

$$F_{lat} = \frac{\pi}{180^\circ}\left(\frac{a^2 b^2}{\left(a^2\cos^2\varphi + b^2\sin^2\varphi\right)^{\frac{3}{2}}} + h\right)$$

where a = 6378137 m is the semi-major axis of WGS-84 ellipsoid
b = 6356752.3142 m is the semi-minor axis of WGS-84 ellipsoid
φ is an average latitude, º
h is the height above WGS-84 ellipsoid (in the table provided, h = 0 m)

Linear Interpolation

As with any tabular data, to find F_{lon} and F_{lat} for latitude that is not listed, the method of linear interpolation between the previous and the next values can be applied. This can be achieved using the following formula:

$$F = F_{prev} + \frac{\varphi - \varphi_{prev}}{\varphi_{next} - \varphi_{prev}}\left(F_{next} - F_{prev}\right)$$

where F is the value of F_{lon} or F_{lat}
φ is the latitude

For example, if latitude is 40.83º, it can be found that F_{lon} = 85394 m/˚ for 40º latitude and F_{lon} = 85394 m/˚ for 41º latitude. Therefore, for 40.83º latitude,

$$F_{lon} = 85394 + \frac{40.83 - 40}{41 - 40}(84135 - 85394) = 84349\, m/^{\circ}$$

Need to Emphasize

- Geographical latitude and height above ellipsoid are the only factors affecting the distance that correspond to 1º of longitude and latitude.
- WGS-84 is one of many models describing the Earth, which is used by GPS.

Related Links

- http://bse.unl.edu/adamchuk/web_ssm/web_GPS.html
- http://bse.unl.edu/adamchuk/web_ssm/web_GPS_tb.html
- http://www.wgs84.com
- http://www.chemical-ecology.net/java/lat-long.htm

Viacheslav Adamchuk and Shana Thomas
Phone: 402-472-8431
E-mail: vadamchuk2@unl.edu
Last updated: May 12, 2008