Basic Geodesy

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Conversions and Transformations

Roger Foster and Dan Mullaney (SNAC)
Coordinate System Analysis Branch (CSAT)

Transformations are used to associate coordinates from one datum/ellipsoid to a different datum/ellipsoid. For example, transformation parameters can be applied to the geographic value of a point in Europe on European Datum 1950/International ellipsoid and using transformation parameters to derive its corresponding value on WGS 84 datum/ellipsoid.

Conversions are used to represent a point on one datum in various formats. For example, a coordinate of a point on WGS 84 datum/ellipsoid reported in Degrees, Minutes, and Seconds; This same point can also be represented by a grid value (projected) such as UTM or MGRS, decimal Degree value, or a Degree and decimal Minute value, Cartesian coordinate value, etc., but the coordinate would still be on the same datum (WGS 84).

Transforming a coordinate from one datum to another does not make the coordinate more accurate. Transformation parameters have errors in them. In order to derive these parameters, geodesists prefer multiple points in the area of interest, with good dispersion that have been surveyed and computed on both datums. (See Figure 1.) In addition, the shift between the datums for the surveyed points needs to be similar in both magnitude and direction. (See Figure 2 on Page 2)

A statistical analysis of these values enables geodesists to compute Molodensky transformation values. (Mikhail Sergeevich Molodensky (1909 – 1991) was a prominent geodesist/geophysicist who developed a set of equations for datum transformations.) A “3-parameter” transformation provides shift values for the x, y, and z axes of the Cartesian coordinates. In addition, the differences between the semi-major axis (a) and the flattening (f) are taken into account. This incorrectly assumes that the axial directions of the two ellipsoids involved are parallel. However, for mapping purposes, these errors are small enough to be ignored. The “7-parameter” transformations do account for the rotational differences in the axes and the scale differences of the ellipsoids, but require a larger number of points with a good distribution and similar magnitudes and direction for the shifted values.

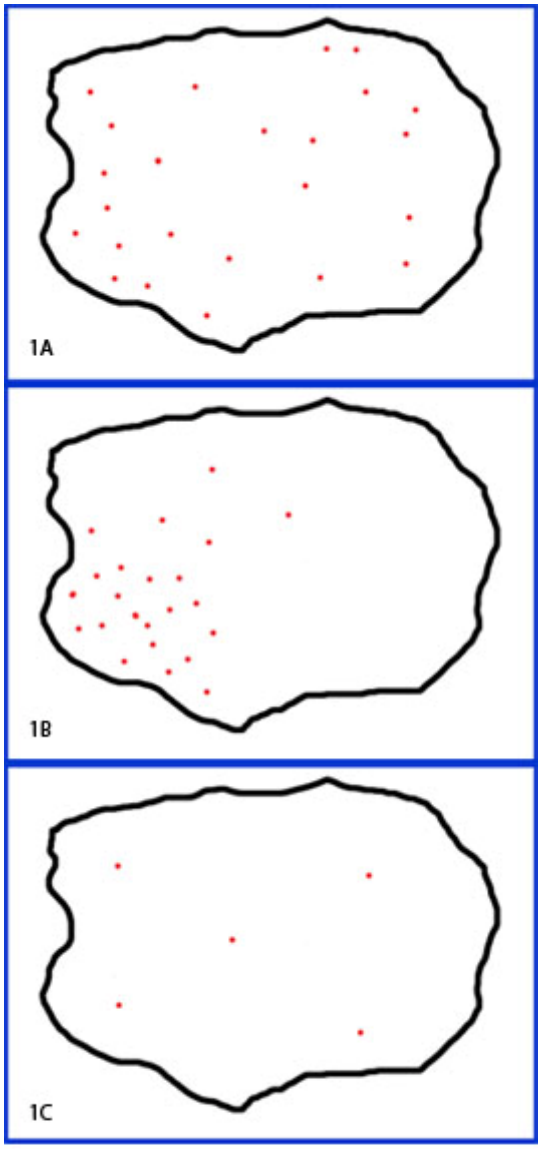

Figure 1A - Good distribution and number of points.
Figure 1B - Good number of points, poor distribution.
Figure 1C - Good distribution, poor number of points.

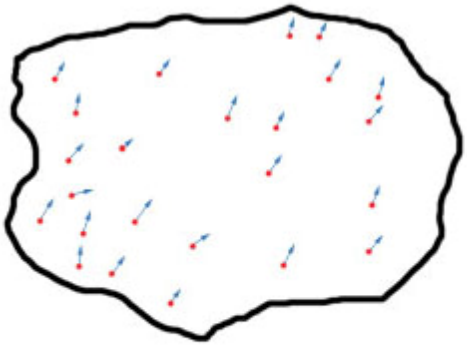

Figure 2 represents points surveyed and computed on the "local" datum as red dots with the blue arrows representing the amount (magnitude) and direction of the shifted values on a different datum.

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Transformation example

A good example of a 3-parameter transformation can be demonstrated by taking a geographic coordinate of a point in Argentina on Campo Inchauspe 1969 datum/International ellipsoid 1924 and deriving its corresponding value on WGS 84 (World Geodetic System 1984) datum/ellipsoid. (The number of stations used for this transformation is twenty and they are well distributed throughout Argentina with the datum origin point located within that country.) The parameters can be located in NIMA TR 8350.2, "National Imagery and Mapping Agency Technical Report (NIMA TR) 8350.2", as follows:

Δa (m)	$\Delta f \times 10^4$	ΔX (m)	ΔY (m)	ΔZ (m)
-251	-0.14192702	-148	136	90

It should be noted that the signs on Delta X, Y, and Z are for transforming coordinates from Campo Inchauspe to WGS 84. If the transformation is in the opposite direction (WGS 84 input transformed to Campo Inchauspe output), the signs on these 3 parameters would be reversed.

Input coordinate of a point in Argentina on Campo Inchauspe 1969 datum: 36° 00' 00.0" S 63° 00' 00.0" W
Output coordinate of the same point in Argentina on WGS 1984 datum: 35° 59' 58.4" S 63° 00' 02.8" W

Conversion examples

We can take the geographic WGS 84 datum/ellipsoid point from above (35° 59' 58.4" S 63° 00' 02.8" W) and convert it to various coordinate formats such as:

35 ° 59.974' S 63 ° 0.047' W	(Degrees, decimal Minutes)
35.99956 ° S 63.00078 ° W	(decimal Degrees)
499930m. E 6016101m. N Zone 20 Southern Hemisphere	(Universal Transverse Mercator (UTM) grid value)
20HMF9993016101	(Military Grid Reference System (MGRS) value)
2345265 X(m.) -4602996 Y(m.) -3728152 Z(m.)	(Geocentric coordinate)

Next Article

The next article will discuss 7 parameter transformations in more detail and multiple regression equations.

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