4.8 MAP PROJECTION

Map projection is the method by which the curved surface of the earth, or a part of it, is represented on a flat surface on a certain scale by making parallels and meridians. In other words, transformation geographical coordinates to a plane grid coordinate system is referred to as map projection.

Globes and maps of the world generally show lines of latitude and longitude, also known as parallels and meridians, that cross each other on the surface of the earth. This is called a graticule. Thus map projection may be defined as the preparation of the graticule on a flat surface. Mathematical formulae are used to construct a graticule on a map, corresponding to the intersecting graticule and meridian on the earth.

Due to the spherical shape of the earth and the plane surface on which this shape has to be represented, cartographers have to devise complex, graphical, geometrical and mathematical methods of transforming the earth, and the resulting transformations are collectively known as map projections. The actual meaning of the word projection is to project an image on something. In a map projection, the network of latitudes and longitudes of a globe are projected on a plane surface. Map projection is defined as the transformation of the spherical network of latitudes and longitudes on a plane surface, irrespective of the method of transformation. A map projection is a way of representing the three-dimensional surface of the earth on a flat piece of paper.

A is a method of showing the earth's surface on a map with least distortions or changes of shape, area, distance, and direction of feature. Globes represent the shape, area, distance and direction of

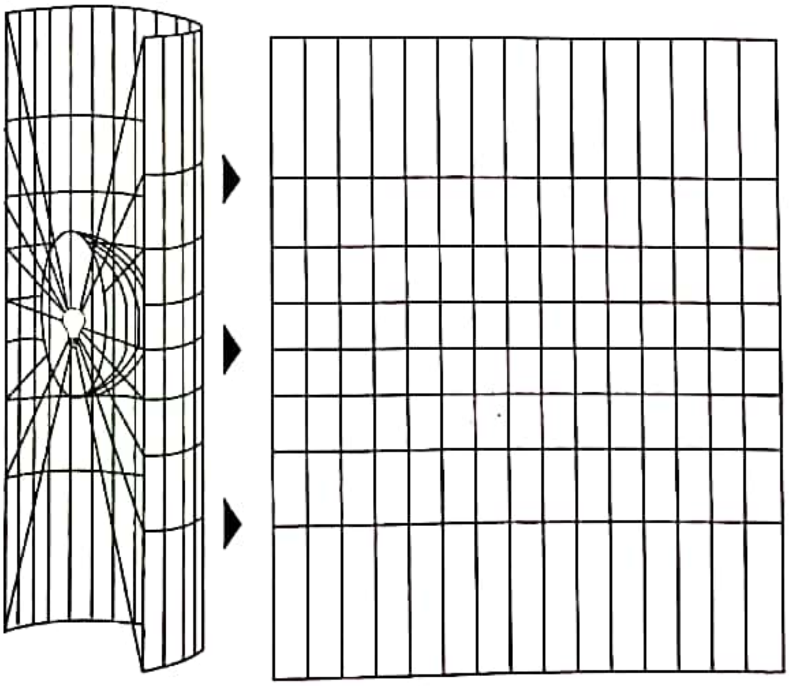

FIGURE 4.11 The graticule of a geographic coordinate system is projected onto a cylindrical projection surface

Scanned with CamScanner

spheroid to representative positions on a flat surface using mathematical algorithms. The first step in projecting from one surface to another is creating one or more points of contact. Each contact is called a point (or line) of tangency. A planar projection is tangential to the globe at one point. Tangential cones and cylinders touch the globe along a line. If the projection surface intersects the globe instead of merely touching its surface, the resulting projection is a secant rather than a tangent case. Whether the contact is tangent or secant, the contact points or lines are significant because they define locations of zero distortion. Lines of true scale are often referred to as *standard line*. In general, distortion increases with the distance from the point of contact. Many common map projections are classified according to the projection surface used. The map projections according to the projection surface are classified as:

1. Conic projection.
2. Cylindrical projection.
3. Planar or azimuthal projection.

4.12.1.1 The Conical Projection Surface

The first type of projection according to the development of surface is the conical projection. Consider a piece of light cardboard rolled up into a cone. It is then placed on a transparent globe. Now the cone and globe will somewhat resemble an ice-cream cone. Wherever the cardboard touches the globe, the most accurate representation would occur. Wherever the cardboard is farther away and not touching the globe, much more distortion will occur.

The simplest conic projection is tangent to the globe along a line of latitude. This line is called the standard parallel. The meridians are projected onto the conical surface, meeting at the apex, or point, of the cone. Parallel lines of latitude are projected onto the cone as rings (see Fig. 4.12). The cone is then cut along any meridian to produce the final conic projection, which has straight converging lines for meridians and concentric circular arcs for parallels. The meridian opposite the cut line becomes the central meridian. In general, the further you move from the standard parallel, the more the distortion is. Thus, cutting off the top of the cone produces a more accurate projection. Conic projections are used for mid-latitude zones that have an east–west orientation.

More complex conic projections contact the global surface at two locations. These projections are called secant projections and are defined by two standard parallels (see Fig. 4.13). It is also possible to define a secant projection by one standard parallel and a scale factor. The distortion pattern for secant projections is different between the standard parallels than beyond them. Generally, a secant projection has less overall distortion than a tangent projection. In still more complex conic projections,

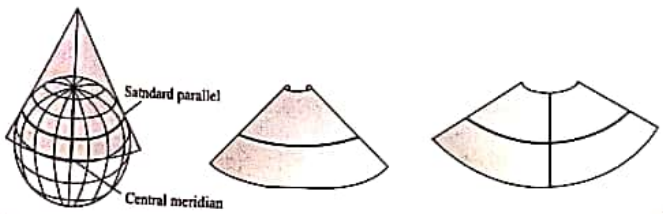

FIGURE 4.12 The conical projection and the developed portion of the plane surface in a conical projection

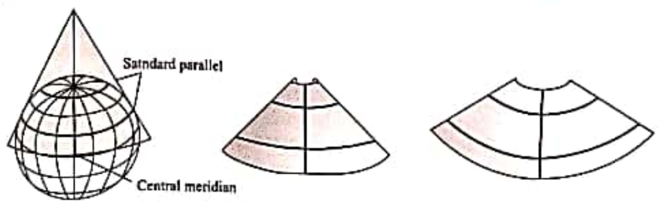

FIGURE 4.13 The secant conical projection and the developed portion of the plane surface in a conical projection

the axis of the cone does not line up with the polar axis of the globe. These types of projections are called oblique.

The representation of geographic features depends on the spacing of the parallels. When equally spaced, the projection is equidistant north–south, but neither conformal nor equal area. An example of this type of projection is the equidistant conic projection. For small areas, the overall distortion is minimal. On the Lambert Conic Conformal projection, the central parallels are spaced more closely than the parallels near the border, and small geographic shapes are maintained for both small-scale and large-scale maps.

4.12.1.2 The Cylindrical Projection Surface

The second type of projection according to the development of surface is the cylindrical projection. Imagine a transparent globe with a light source that casts the shadow of the outlines of its graticule and continents. Imagine rolling a piece of light cardboard into a cylinder around the globe and the shadow cast on to the piece of light cardboard could be captured. The resulting image, when rolled flat, would be a cylindrical projection (see Fig. 4.14). Like conic projections, cylindrical projections can also have tangent or secant cases. The Mercator projection is one of the most common cylindrical projections, and the equator is usually its line of tangency. Meridians are geometrically projected onto the cylindrical surface, and parallels are mathematically projected. This produces graticular angles of 90 degrees. The cylinder is 'cut' along any meridian to produce the final cylindrical projection. The meridians are equally spaced, while the spacing between parallel lines of latitude increases toward the poles. This projection is conformal and displays true direction along straight lines.

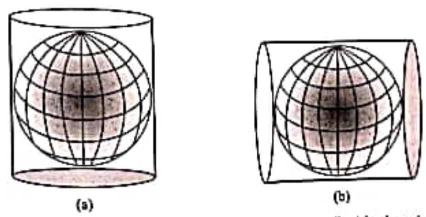

FIGURE 4.14 (a) Normal and (b) transverse cylindrical projections

Scanned with CamScanner

On a Mercator projection, rhumb lines (lines of constant bearing) are straight lines, but most great circles are not. For more complex cylindrical projections the cylinder is rotated, thus changing the tangent or secant lines. Transverse cylindrical projections such as the transverse Mercator use a meridian as the tangential contact or lines parallel to meridians as lines of secancy.

The standard lines then run north–south, along which the scale is true. Oblique cylinders are rotated around a great circle line located anywhere between the equator and the meridians. In these more complex projections, most meridians and lines of latitude are no longer straight. A Mercator projection does not show the north or south pole.

In all cylindrical projections, the line of tangency or lines of secancy have no distortion, and thus are lines of equidistance. Other geographical properties vary according to the specific projection.

4.12.1.3 The Azimuthal Projection or Plane Projection Surface

Planar projections project map data onto a flat surface touching the globe. A planar projection is also known as an azimuthal projection or a zenithal projection. This type of projection is usually tangent to the globe at one point, but may be secant also. The point of contact may be the north pole, the south pole, a point on the equator, or any point in between. This point specifies the aspect and is the focus of the projection. The focus is identified by a central longitude and central latitude. Possible aspects are polar, equatorial, and oblique. The shadow that was cast on the cardboard, the way the shadow lands on the cardboard would be called an azimuthal or plane projection (see Fig. 4.15).

Polar aspects are the simplest form. Parallels of latitude are concentric circles centred on the pole, and meridians are straight lines that intersect with their true angles of orientation at the pole. In other aspects, planar projections will have graticular angles of 90 degrees at the focus. Directions from the focus are accurate. Great circles passing through the focus are represented by straight lines; thus, the shortest distance from the centre to any other point on the map is a straight line. Patterns of area and shape distortion are circular about the focus. For this reason, azimuthal projections accommodate circular regions better than rectangular regions. Planar projections are used more often to map polar regions. Some planar projections view surface data from a specific point in space. The point of view determines how the spherical data is projected onto the flat surface. The perspective from which all locations are viewed varies between the different azimuthal projections. The perspective point may be the centre of the earth, a surface point directly opposite from the focus, or a point external to the globe, as if seen from a satellite or another planet.

(a) (b) (c)

FIGURE 4.15 Planar projections. (a) Polar, (b) equatorial and (c) oblique

Scanned with CamScanner