Geographic Information Systems 2018/19
Week 2, Topic 1

Mark Foley
School of Computing
DIT, Kevin Street

mark.foley@dit.ie

In this session...

The shape of the Earth

From an approximate sphere to flat maps

Geographic Coordinate Systems

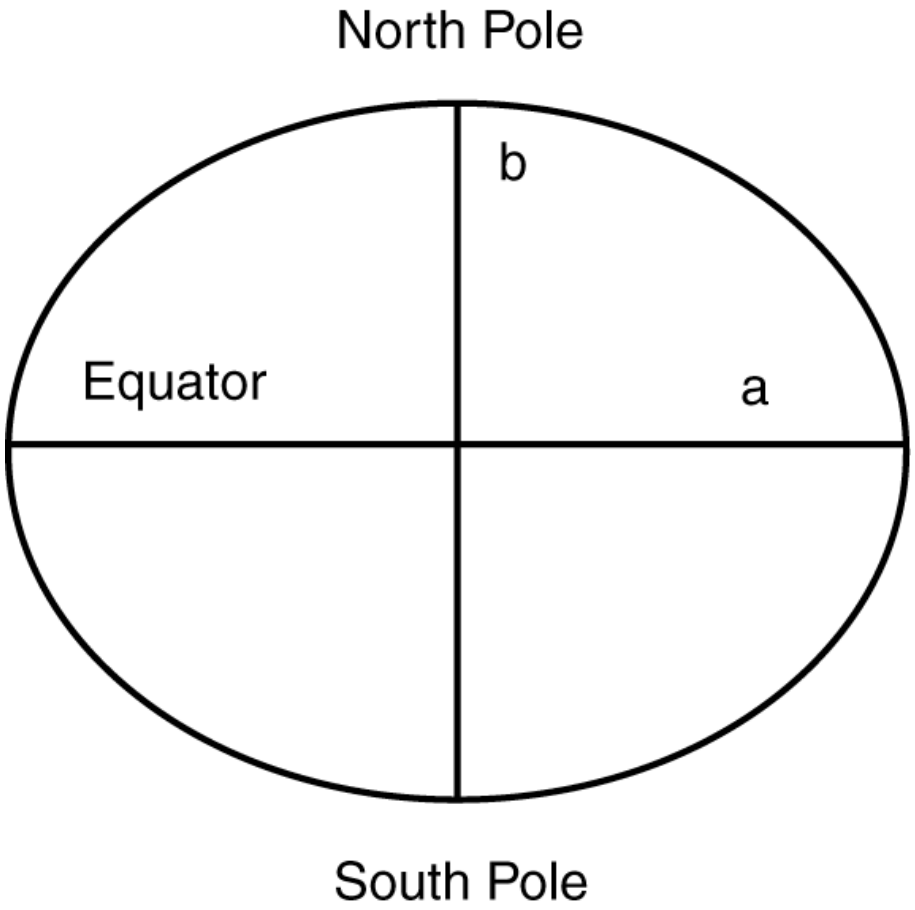
Map Projections in general

The shape of the Earth *(and why this is important)*

The simplest model of the Earth is a sphere, which is typically used in discussing map projections.

However, the Earth is not a perfect sphere: the Earth is wider along the equator than between the poles. Therefore a better approximation to the shape of the Earth is a *spheroid*, also called *ellipsoid*, an ellipse rotated about its minor axis.

The shape of the Earth



The flattening is based on the difference between the semimajor axis **a** and the seminor axis **b**. Different assumptions about these parameters will result in incompatible coordinate reference systems.

Datum

A datum is a mathematical model of the Earth, which serves as the reference or base for calculating the geographic coordinates of a location.

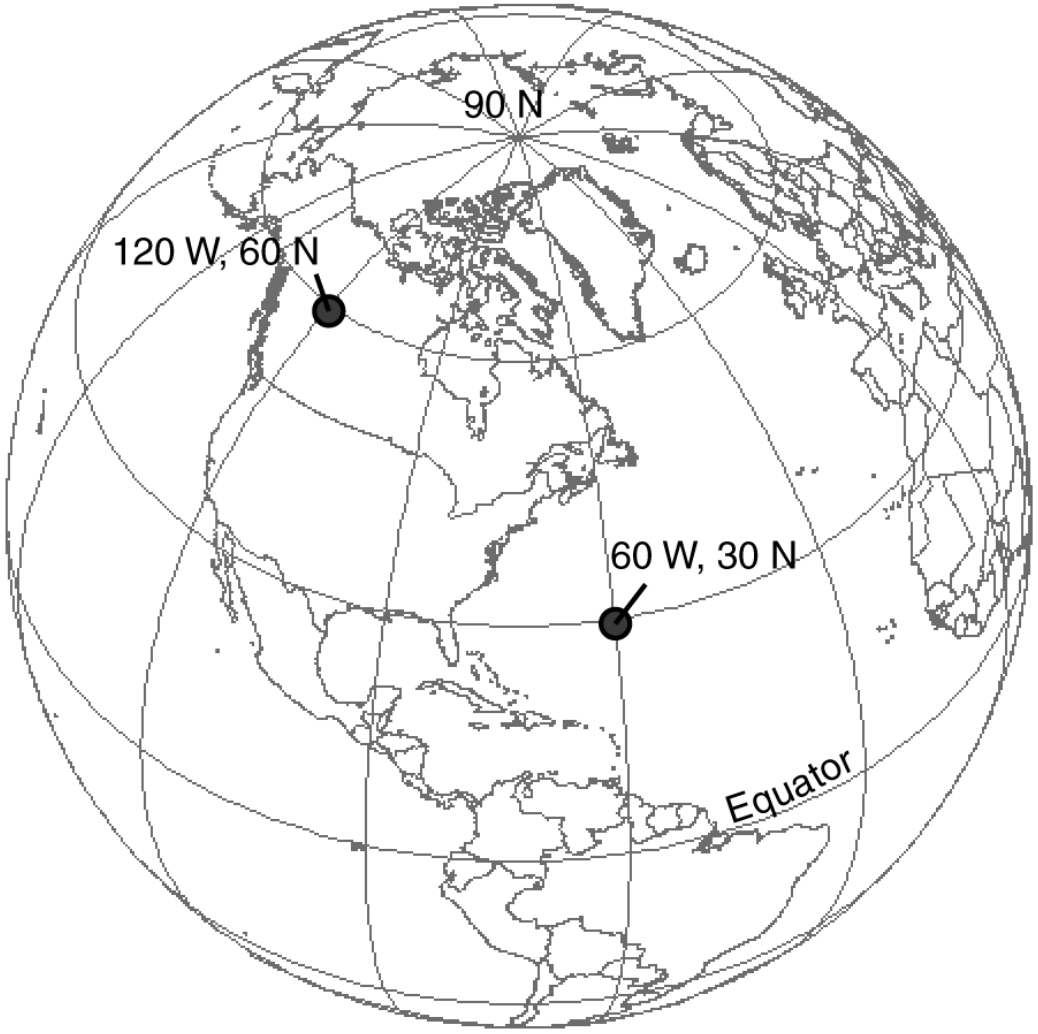
A shift of the datum will result in the shift of positions of points.

Geographic Coordinate System

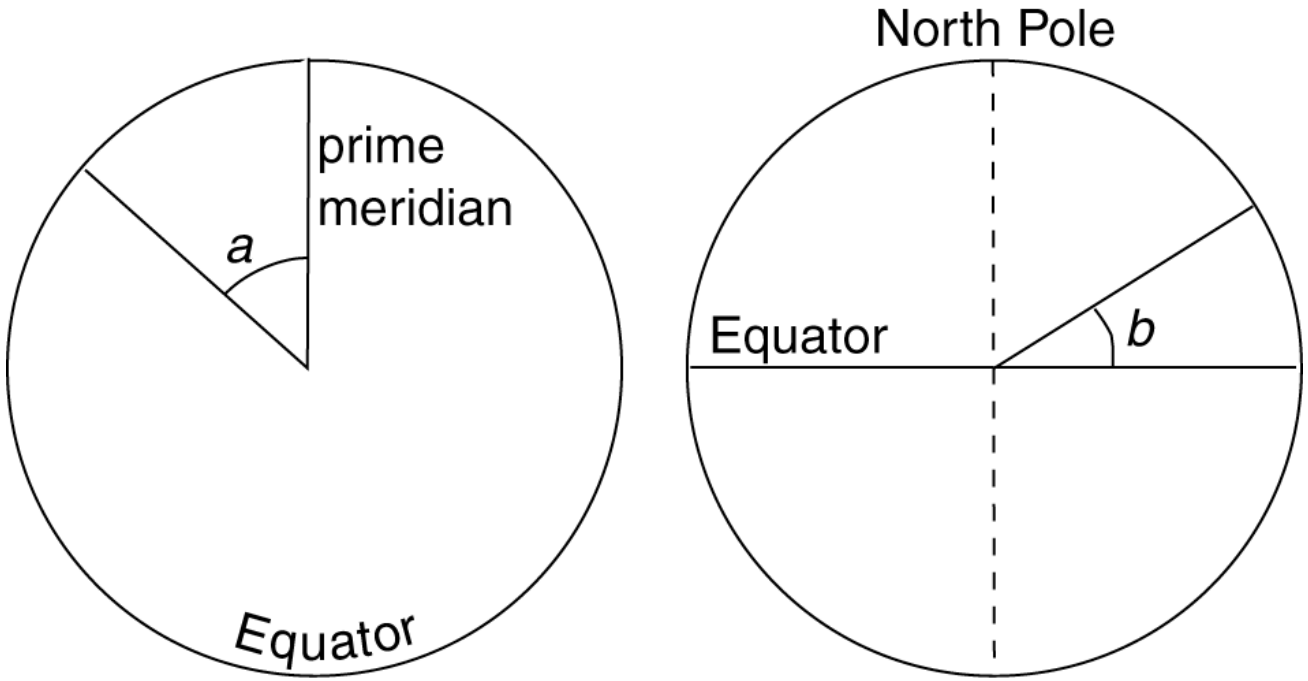
The geographic coordinate system is the location reference system for spatial features on the Earth's surface.

The geographic coordinate system is defined by longitude and latitude.

Geographic Coodinate System



Latitude and Longitude



A longitude reading is represented by **a** on the left, and a latitude reading is represented by **b** on the right. Both longitude and latitude readings are angular measures.

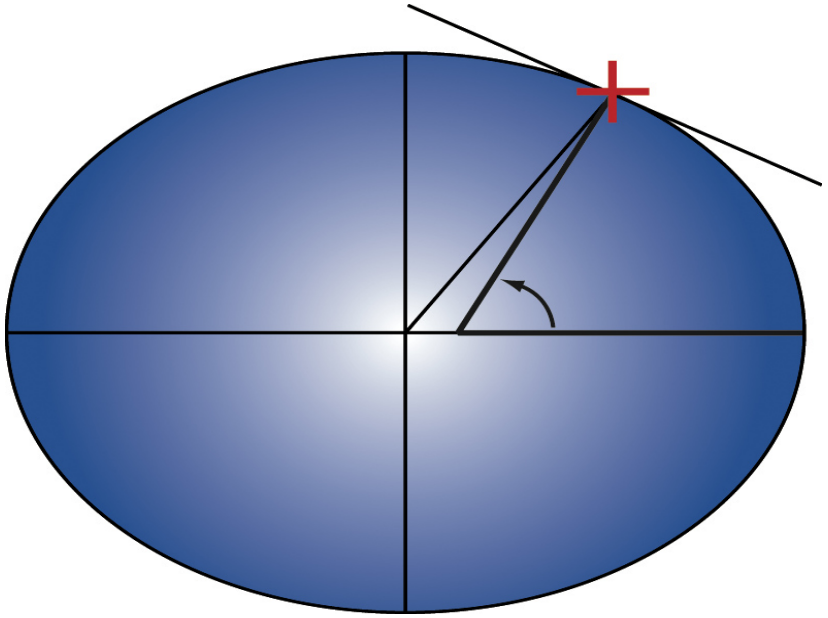
Definition of longitude. The Earth is seen here from above the North Pole, looking along the Axis, with the Equator forming the outer circle. The location of Greenwich defines the Prime Meridian.

Ellipsoids and Latitude

Because the Earth is not shaped precisely as an ellipsoid, initially each country felt free to adopt its own as the most accurate approximation to its own part of the Earth

Differences between ellipsoids can be as much as 200 metres.

Latitude is the angle between a perpendicular to the surface and the plane of the Equator.



Projections

Problem: how to flatten an (approximate) sphere (the Earth) onto a 2D surface

- There are many reasons for wanting to project the Earth's surface onto a plane, rather than deal with the curved surface
- The paper used to output GIS maps is flat
- Flat maps are scanned and digitized to create GIS databases
- Rasters are flat, it's impossible to create a raster on a curved surface
- The Earth has to be projected to see all of it at once
- It's much easier to measure distance on a plane

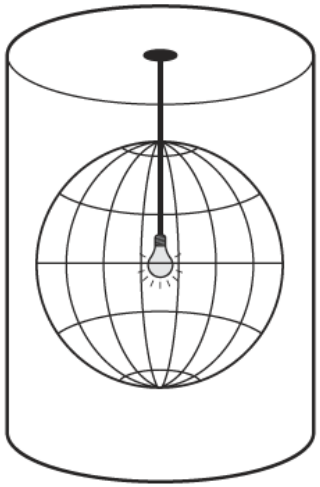
Projections

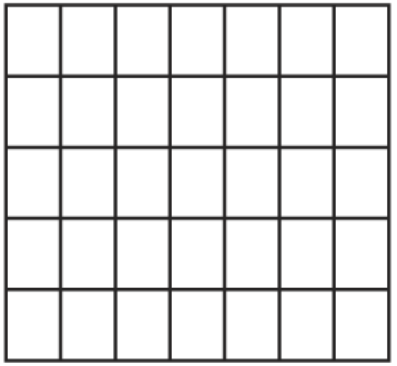
A map projection is a systematic arrangement of parallels and meridians on a plane surface.

Cartographers group map projections by the preserved property into conformal, equal area or equivalent, equidistant, and azimuthal or true direction.

Cartographers also use a geometric object (a cylinder, cone, or plane) and a globe (i.e., a sphere) to illustrate how to construct a map projection.

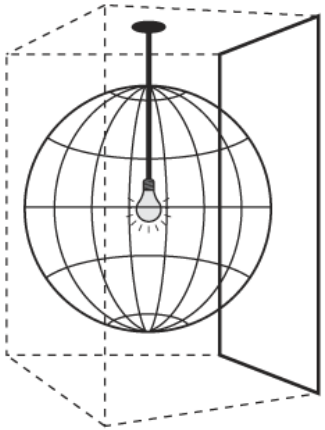
Projections

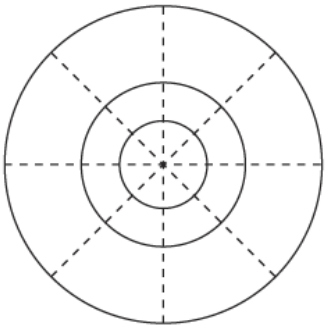




- Continuous picture of the Earth
- Countries near the equator in true relative positions
- Distance increases between countries located towards top and bottom of image
- The view of the poles is very distorted
- Area for the most part is preserved

(a) Cylindrical projection *(light in a circular room analogy)*

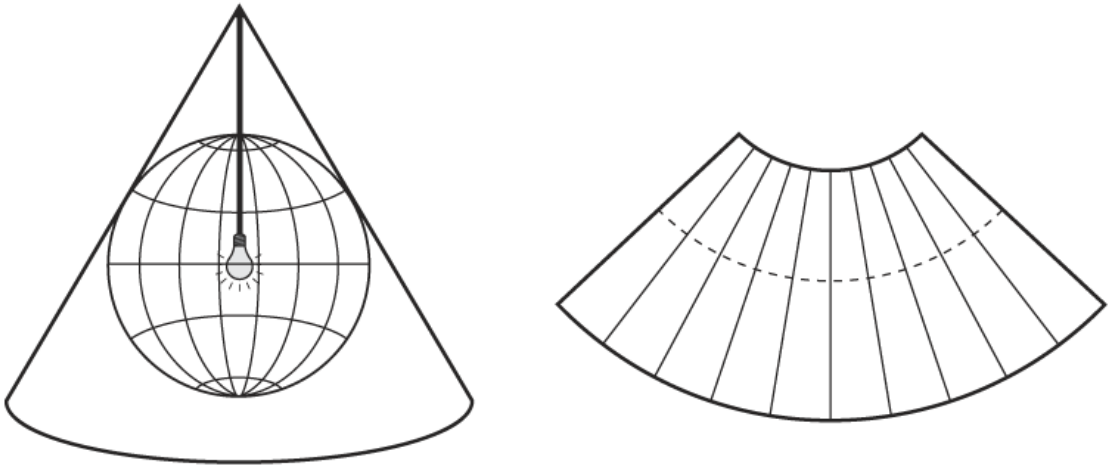




- Only a part of the Earth's surface is visible
- The view will be of half the globe or less
- Distortion will occur at all four edges
- Distance for the most part is preserved

(b) Azimuthal projection *(light in a square room with flat walls analogy)*

Projections



- Area is distorted
- Distance is very distorted towards the bottom of the image
- Scale for the most part is preserved

(c) Conic projection *(light in a tepee analogy)*

Any projection must distort the Earth in some way.

Two types of projections are important in GIS

- Conformal property: Shapes of small features are preserved: anywhere on the projection the distortion is the same in all directions
- Equal area property: Shapes are distorted, but features have the correct area

Both types of projections will generally distort distances.

Coming next...

Commonly used map projections

Projected Coordinate Systems

Irish Grid and Irish Transverse Mercator