Geography 38/42:286
GIS 1

Topic 4: Geodesy and Map Projections

Chapter 2: Chang
Chapters 2 & 3: Dent et al.

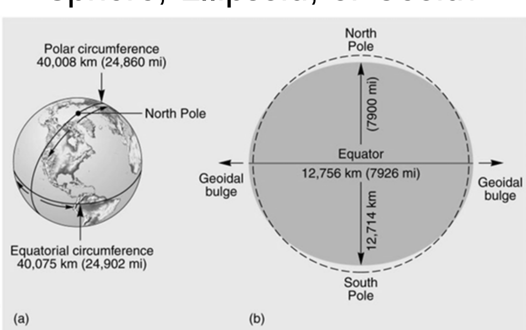
1

Geodesy

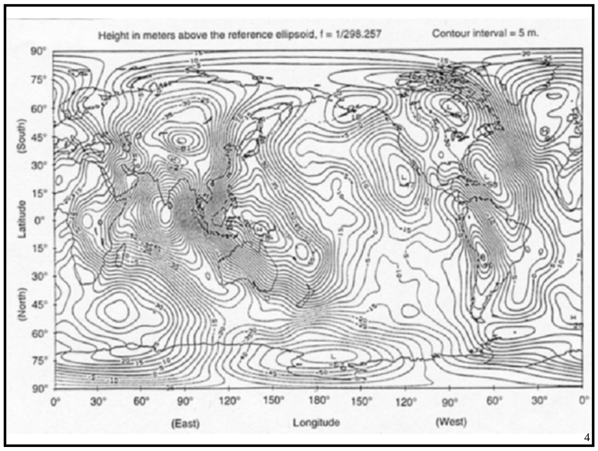
- What is it?
- Why is this important?

2

Sphere, Ellipsoid, or Geoid?



3



4

Sphere, Ellipsoid or Geoid?

- The authalic sphere
  - Ten metres error on a map of Brandon!
- No single ellipsoid works best
- So, a series of “best fit” ellipsoids were developed

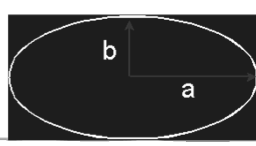
5

Ellipsoids

- Described in terms of the amount of polar flattening (f) and the eccentricity (e)

$f = (a-b)/a$ **$e = [(a^2 - b^2)/a^2]^{1/2}$**

a = equatorial radius
b = polar radius



6

Name	Date	Equatorial Radius *a* (meters)	Radius *b* (meters)	Polar Flattening
WGS 84	1984	6,378,137	6,356,752.3	1/298.257
GRS 80*	1980	" "	" "	" "
WGS 72	1972	6,378,135	6,356,750.5	1/298.26
Australian	1965	6,378,160	6,356,774.7	1/298.25
Krasovsky	1940	6,378,245	6,356,863	1/298.3
Internat'l	1924	6,378,388	6,356,911.9	1/297
Clarke	1880	6,378,249.1	6,356,514.9	1/293.46
Clarke	1866	6,378,206.4	6,356,583.8	1/294.98
Bessel	1841	6,377,397.2	6,356,079.0	1/299.15
Airy	1830	6,377,563.4	6,356,256.9	1/299.32
Everest	1830	6,377,276.3	6,356,075.4	1/300.8

*Geodetic Reference System 1980, adopted by the International Association of Geodesy.

7

The Datum

- Based on a particular ellipsoid
- Orientation/fit establishes a geodetic datum
- Datum defines a coordinate system & a set of control pts.
- If you switch datums, your position changes

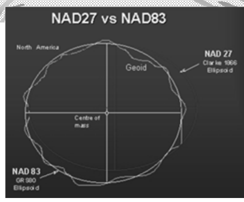
8

The Datum

Name	Date	Equatorial Radius *a* (meters)	Radius *b* (meters)	Polar Flattening
WGS 84	1984	6,378,137	6,356,752.3	1/298.257
GRS 80*	1980	" "	" "	" "
WGS 72	1972	6,378,135	6,356,750.5	1/298.26
Australian	1965	6,378,160	6,356,774.7	1/298.25
Krasovsky	1940	6,378,245	6,356,863	1/298.3
Internat'l	1924	6,378,388	6,356,911.9	1/297
Clarke	1880	6,378,249.1	6,356,514.9	1/293.46
Clarke	1866	6,378,206.4	6,356,583.8	1/294.98
Bessel	1841	6,377,397.2	6,356,079.0	1/299.15
Airy	1830	6,377,563.4	6,356,256.9	1/299.32
Everest	1830	6,377,276.3	6,356,075.4	1/300.8

*Geodetic Reference System 1980, adopted by the International Association of Geodesy.

9



NAD27

10

NAD83

- Based on GRS80 ellipsoid
- Origin at centre of Earth's mass
- Locations shifted by as much as 25 metres

11

12

13

14

So What?

- You need to know the coordinate system, ellipsoid and datum when you:

1.
2.
3.

15

Remember

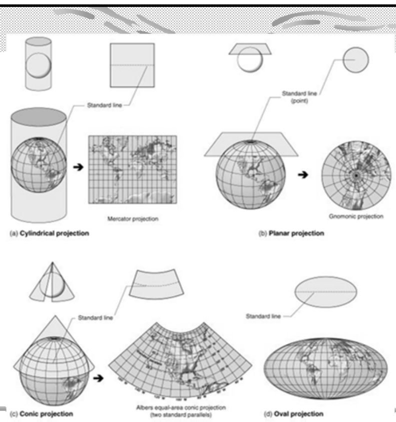
- Ellipsoid related errors:
  - Negligible at small scales
  - Significant at large scales

16

Map Projections

- Def'n: transformation of the spherical representation of Earth to a flat map
- Results in distortion
  - Minimized for small areas
  - More significant for large areas

17

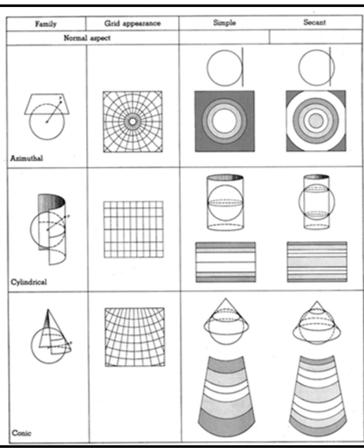


18

Standard Lines and Points

- A line(s) or point on a map that has the same scale (dimensions) as the reference globe
- No distortion
- SF = 1.0

19



20

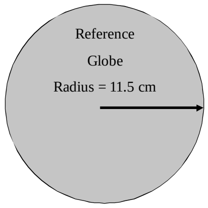
Properties of Map Projections

- All projections result in distortion of:
  1.
  2.
  3.
  4.
- It's a choice

21

Scale on a Globe

- Called nominal scale
- No distortion
- Same everywhere



NS = Earth Radius/Globe Radius
= 6,371.3 km/11.5 cm
= 637,130,000/11.5 cm
= 55,402,608
NS is 1:55,402,608

22

Scale on a Map

- Distortion, so reduction isn't the same everywhere
- Map scale differs from nominal scale
- Scale Factor = map scale/nominal scale

23

Assessing Map Distortion

- Two methods of evaluating map distortion:
  1. Graphical method
     -
     -
     -
  2. Tissot's Indicatrix
     -
     -
     -

24

Tissot's Theorem

- At any point on a reference globe there are an infinite number of paired orthogonal directions
- When transformed to map they may or may not remain orthogonal
- Tissot's theorem states that regardless of the type of transformation, at each point on a sphere there is at least one pair of orthogonal directions that will remain orthogonal when transformed
- Referred to as principle directions; a and b

25

Tissot's Theorem (con't)

- Not important what directions actually are
- Tissot proved that these represent the max and min deviations from SF at a point on the map
- On a globe SF = 1 everywhere, and a = b
- On a map SF = 1 and a = b only along standard lines or at a standard point
- Elsewhere, a = max deviation, b = min deviation

26

Tissot's Indicatrix

- Graphical device used to measure:
  - type and <u>amount</u> of
  - at a particular point on a map

27

Tissot represented a finite point on the reference globe with a circle of radius 1 (Red Circle).

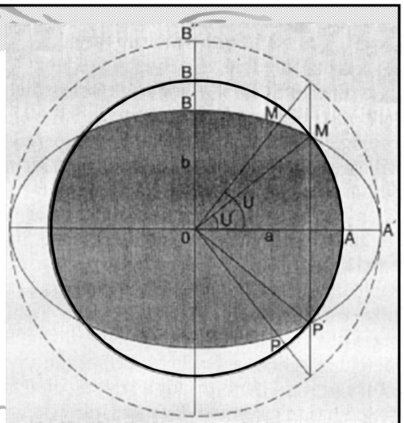
SF in principle directions OA = a and OB = b is 1.

If length of a = b then projection is conformal.

If a x b = 1.0 projection is equivalent.

S = areal distortion = a x b

2Ω = maximum angular distortion = 2(U – U')



28

Blue circle represents distortion at a point on a map.

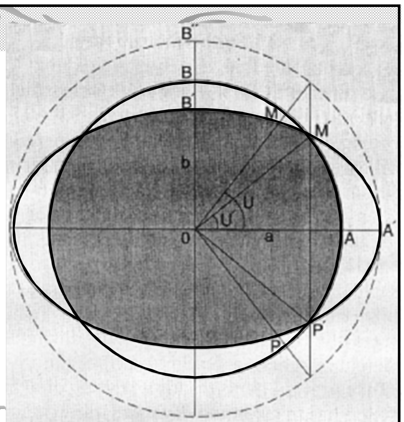
a = OA' and b = OB'

a = 1.25 and b = 0.80

S = a x b = 1.0, so this is an equivalent projection.

Length a ≠ b, so this is not a conformal projection.

2 Ω = 2(U – U') = 2 x 12.5° = 25 °



29

Green circle represents distortion at a point on another map.

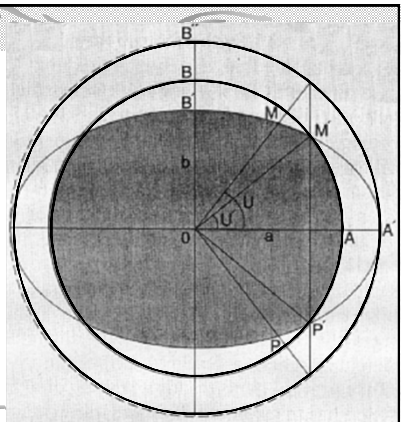
a = OA' and b = OB"

a = 1.25 and b = 1.25

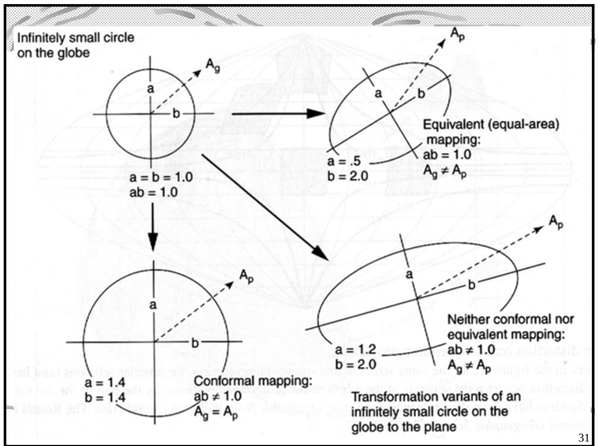
S = a x b = 1.5625 so not an equivalent projection.

Length a = b so this is a conformal projection.

2Ω = 0 °



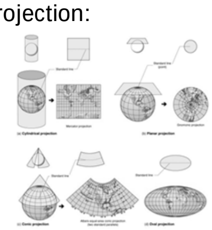
30



31

Types of Projections

- Two classification schemes:
  - One based on origin of projection:
    1.
    2.
    3.



32

Types of Projections

- Two classification schemes:
  - The other based on the property preserved:
    1.
    2.
    3.
    4.

33

Selecting a Map Projection

- Right projection depends on:
- Sometimes not your choice:

34

Remember

- Projection errors:
  - Greatest at small scales (large areas)
    - Lots of stretching/pulling
  - Minimized at large scales (small areas)
    - Less stretching/pulling
- Ellipsoid related errors:
  - Greatest at large scales (small areas)
    - Deviation b/w ellipsoid and geoid is significant
  - Minimized at small scales (large areas)
    - Deviation b/w ellipsoid and geoid is imperceptible

35