



# *Cartography*

# CARTOGRAPHY

What is Cartography?

Cartography is at the same time art and science, but we can consider also as “communication” and “analysis”.

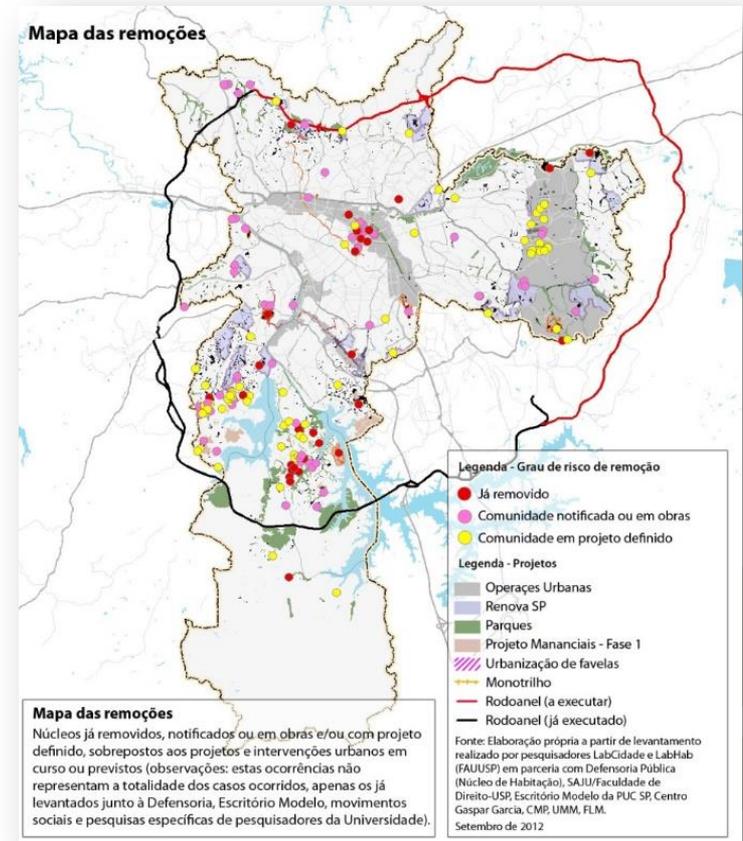
All studies and scientific operations, technical and artistic involved in mapping from the results of direct or documental observation. (International Cartographic Association)



# CARTOGRAPHY

Map, Chart, Plant, Sketch and ...

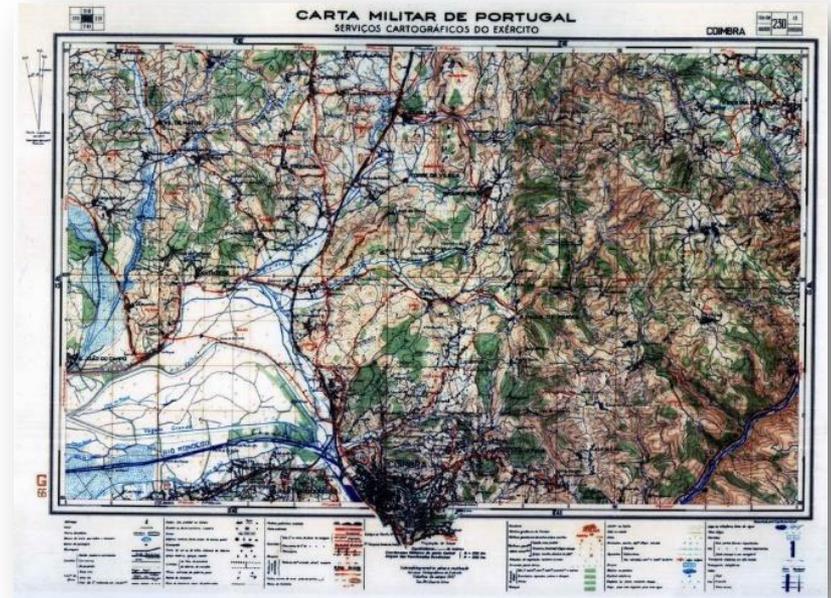
**Map:** Graphic representation, usually a flat surface at a certain scale, with the representation of physical and cultural accidents of the surface of the Earth, or a planet or satellite. The positions of accidents must be accurate, according generally with a coordinate system. It is also used to denote all or part of the celestial sphere surface .



# CARTOGRAPHY

Mapa, Carta, Planta, Croqui e ...

**Chart:** Representation of natural and artificial aspects of the Earth, for the practical purposes of human activity, especially the precise evaluation of distances, directions and precise location, areas and detail; flat representation, generally in medium or large scale, a surface of the Earth, divided into leaves, systematically, following a national or international level.



# CARTOGRAPHY

Essential attributes

**Scale:** Relationship between the measure of an object (or distance) shown on the map and its actual measurement.

**Projeção:** tries to correct the issues related to the transformation of the spherical surface (the earth) a flat surface (paper).

**Symbolism:** representation of objects and phenomena.

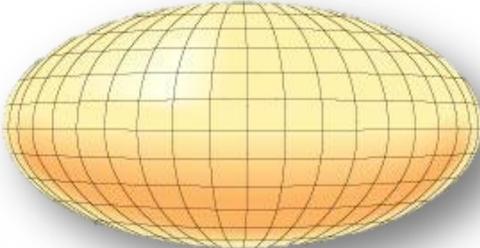


# Earth Representations

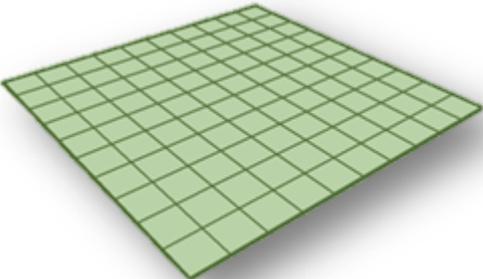
Spheroid



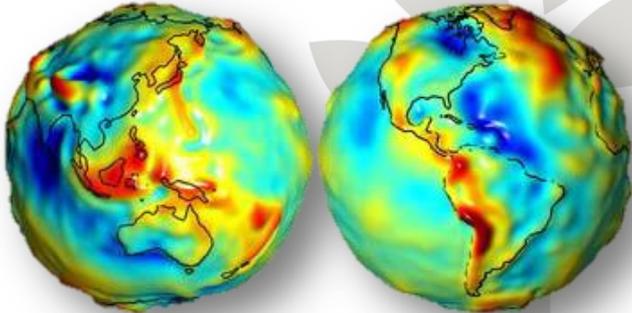
Ellipsoid



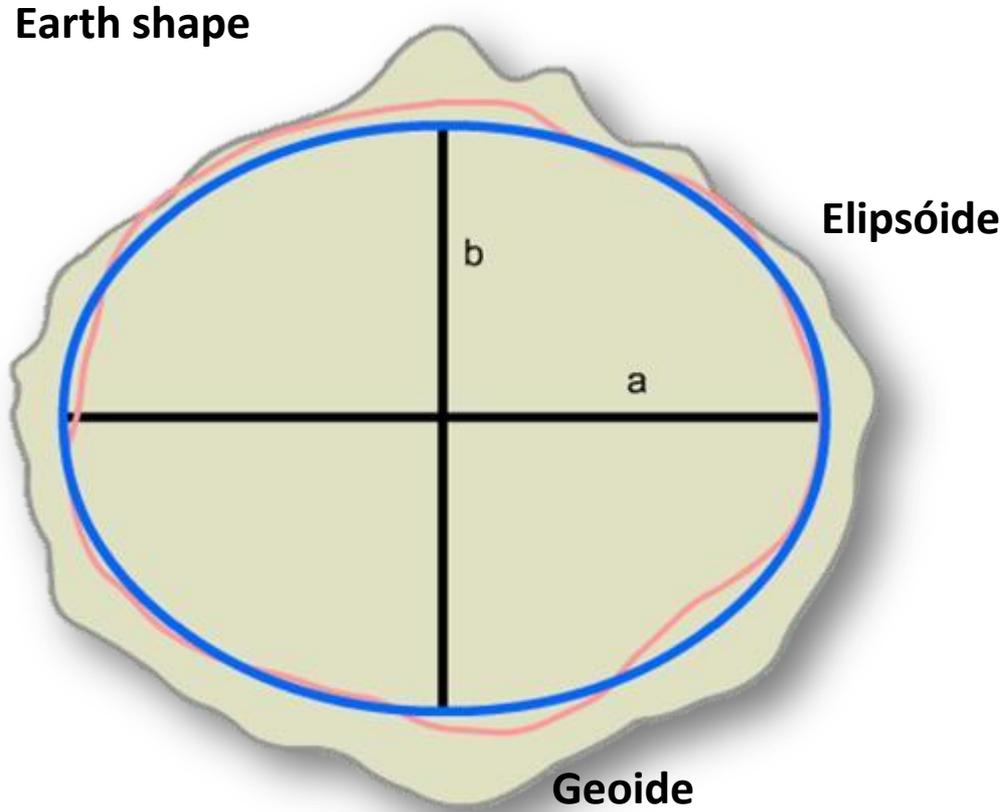
Plan



Geoid



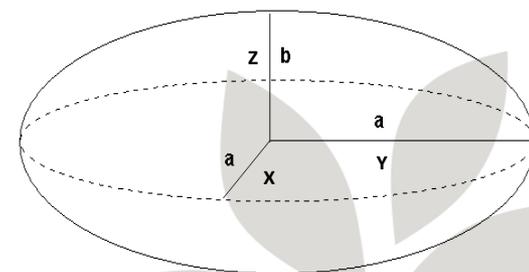
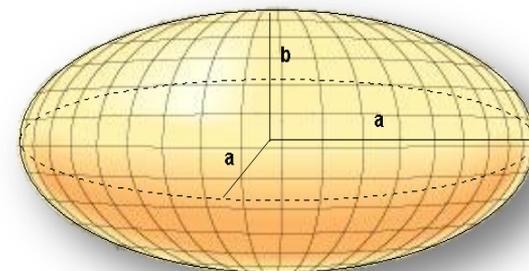
# Earth Representations



# Spheroid or ellipsoid

Historic of ellipsoidal representations of the Earth

Name	Equatorial axis: a (m)	Polar axis: b (m)	Inverse flattening $1/f$
Shpere (6371 km)	6 371 000	6 371 000	$\infty$
Airy 1830	6 377 563.4	6 356 256.9	299.324 975 3
Clarke 1866	6 378 206.4	6 356 583.8	294.978 698 2
Bessel 1841	6 377 397.155	6 356 078.965	299.152 843 4
International 1924	6 378 388	6 356 911.9	297
Krasovsky 1940	6 378 245	6 356 863	298.299 738 1
South American 1967	6 378 160	6 356 774.719	298.25
GRS 1980	6 378 137	6 356 752.3141	298.257 222 101
WGS 1984	6 378 137	6 356 752.3142	298.257 223 563



$$\frac{x^2 + y^2}{a^2} + \frac{z^2}{b^2} = 1$$

# SAD69

South American Datum (SAD), South American Regional Reference System, since 1969

## Ellipsoid: SGR-67

Equatorial Radius  $a = 6\,378\,160$  m, flattening  $f = 1/298.25$

**Position:**  $\phi = -19^{\circ}45' 41,6527''$ ,  $\lambda = -48^{\circ}06' 04,0639''$  (Chuá)

(regional, initially defined through astronomical measurements. Updated in 1996 using GPS and Doppler techniques).

for more detailed information: [ftp://geoftp.ibge.gov.br/documentos/geodesia/sisref\\_2.pdf](ftp://geoftp.ibge.gov.br/documentos/geodesia/sisref_2.pdf)



# WGS84

World Geodetic System (WGS), global reference system, since 1984 (last update, 2004) (Actual version: G1150)

**Ellipsoid:** WGS-84

Equatorial Radius  $a = 6\,378\,137$  m, flattening  $f = 1/298.257223563$

**Position:** centered on the earth's center of mass

(global and defined through satellite measurements)

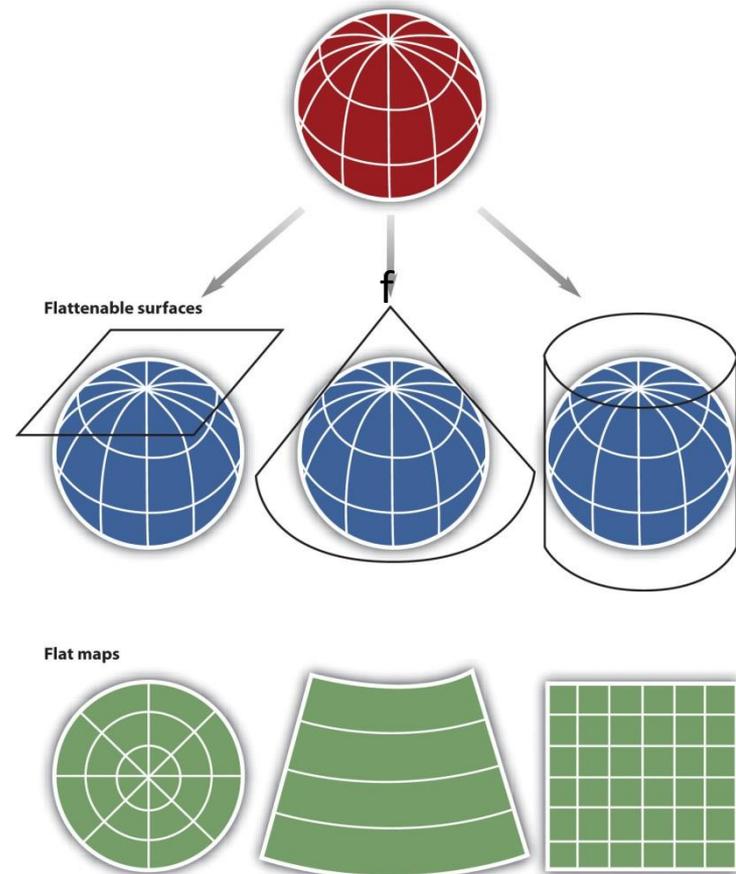
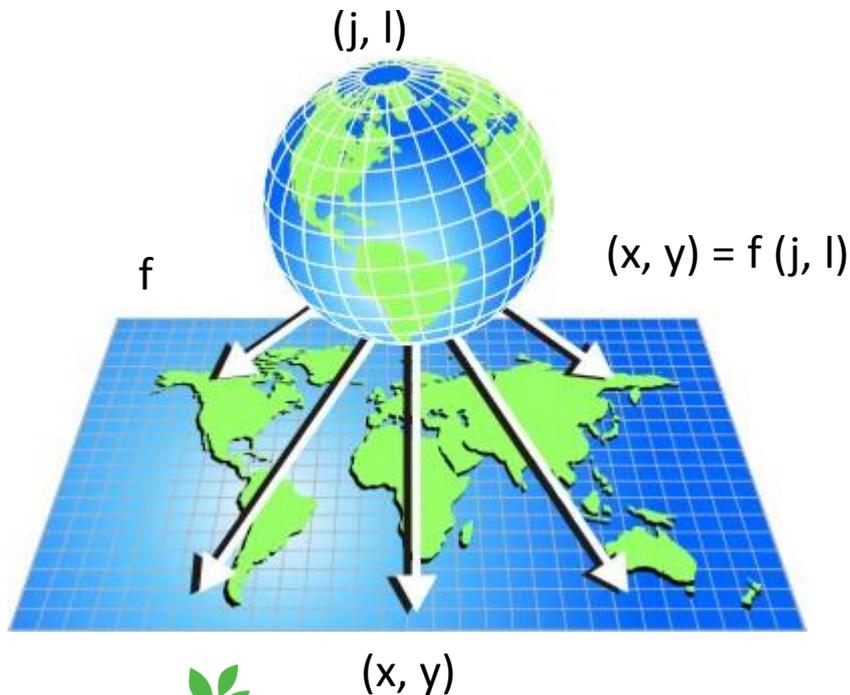
More info:

[http://earth-info.nga.mil/GandG/publications/tr8350.2/tr8350\\_2.html](http://earth-info.nga.mil/GandG/publications/tr8350.2/tr8350_2.html)



# Cartographic Projections

Projections are mathematical formulas ( $f$ ) that allow to represent a point of the surface of the earth ( $j, l$ ) in a map ( $X, Y$ )



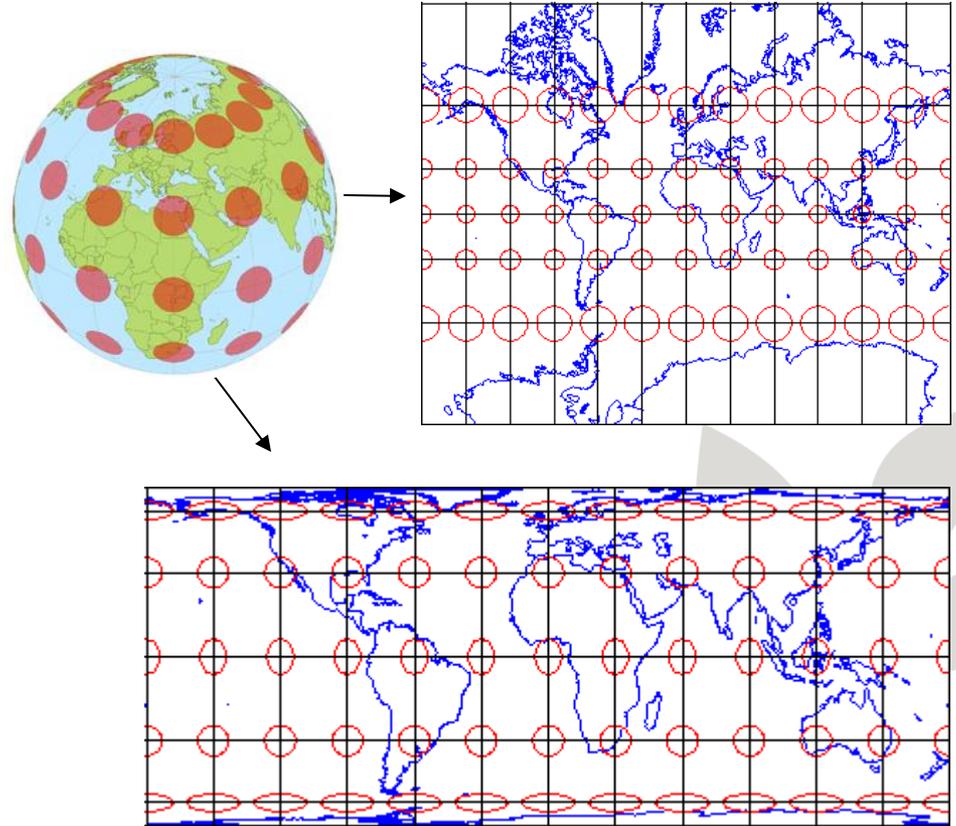
Source: <http://2012books.lardbucket.org/books/>

# Cartographic Projections

No projection allows us to flatten the globe without distorting it.

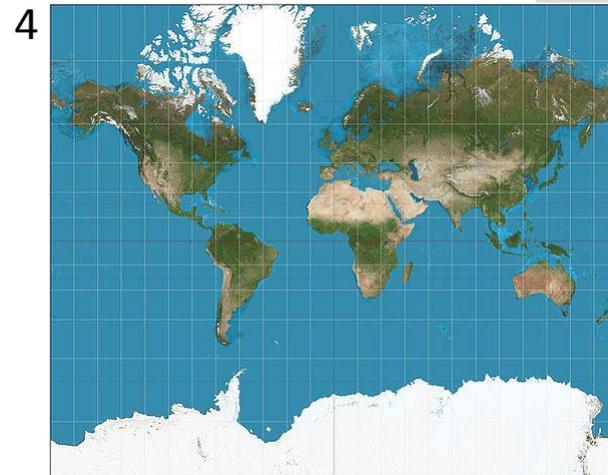
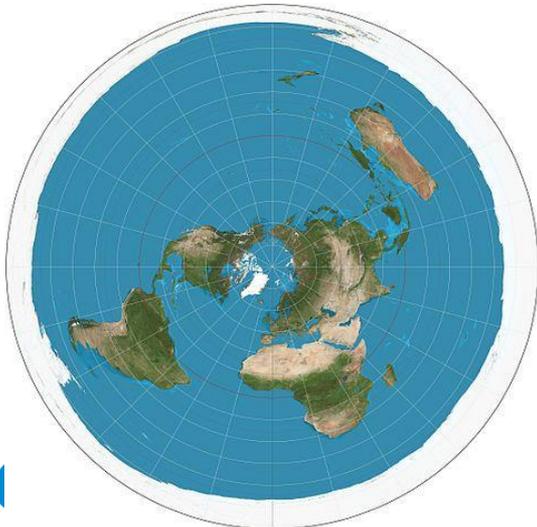
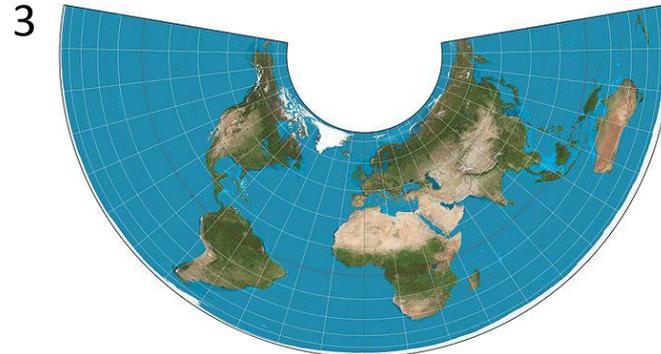
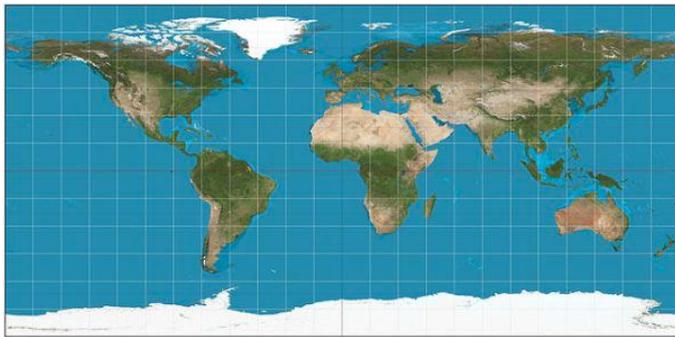
## Deformations:

- ❑ Deformations are larger for regions far from standard elements (lines or points).
- ❑ Ellipse of distortion or Tissot's indicatrix help us to visualize what type of distortion a map projection has caused, how much distortion occurred, and where it occurred.



# Cartographic Projections

The figures below show distortions resulting from different projections. The globe is successively mapped by (1) a projection lat-long, (2) azimuthal, (3) and Albers (4) Mercator.





# Cartographic Projections

- Common Projection Systems
  - Latitude Longitude System (Equirectangular projection)
  - UTM (Cylindrical conform)
  - Albers (Conic equivalent)
  - Lambert (Conic conform)



# Latitude – Longitude System

(Geographic's or geodesic's coordinates)

To place a point on a model of Earth's surface, two coordinates are used:

- ❑ **Latitude:** ranges from  $-90^\circ$  to  $0^\circ$  (South) and from  $0^\circ$  to  $90^\circ$  (North).
- ❑ **Longitude:** ranges from  $0$  (Prime meridian: Greenwich) to  $180^\circ$  (East) and from  $-180^\circ$  to  $0^\circ$  (West)

**Meridians** are lines of constant longitude

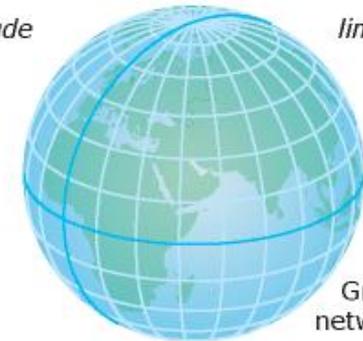
**Parallels** are circles of constant latitude.



Parallels  
*lines of latitude*



Meridians  
*lines of longitude*



Graticular  
network

# Latitude – Longitude System

(Equirectangular projection)

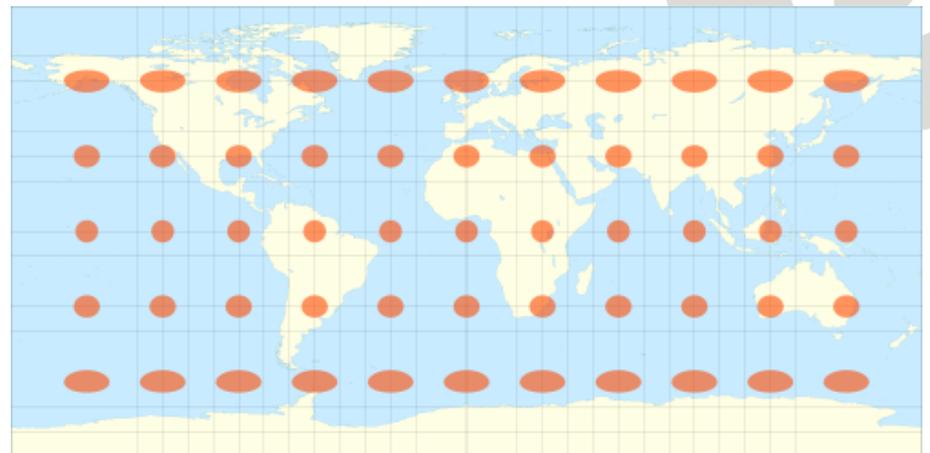
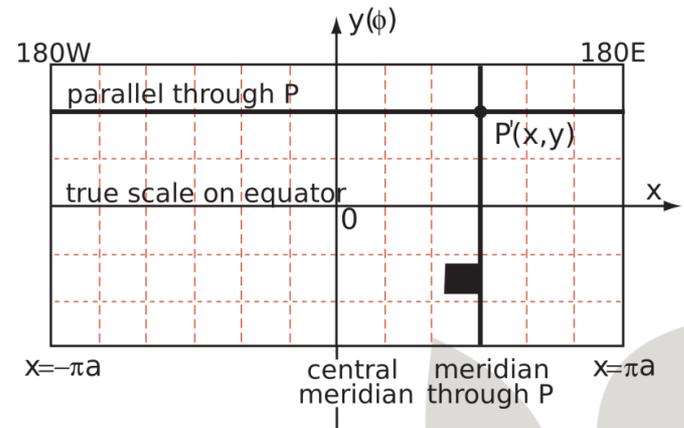
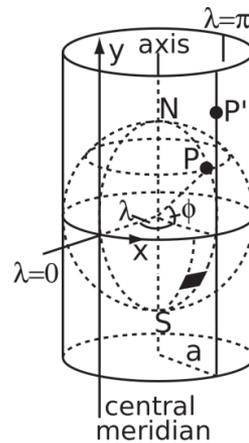
It is also called the "non-projection", or plate carre, since the horizontal coordinate is simply longitude, and the vertical coordinate is simply latitude, with no transformation or scaling applied.

This cylindrical equidistant projection presents the following characteristics:

**Meridians:** equally spaced straight parallel lines half as long as the Equator;

**Parallels:** equally spaced straight parallel lines, perpendicular to and having same spacing as meridians;

**Poles:** straight lines equal in length to the Equator.



# Latitude – Longitude System

(Geographic's or geodesic's coordinates)



Lat max=?  
Long max=?

Lat min=?  
Long min=?

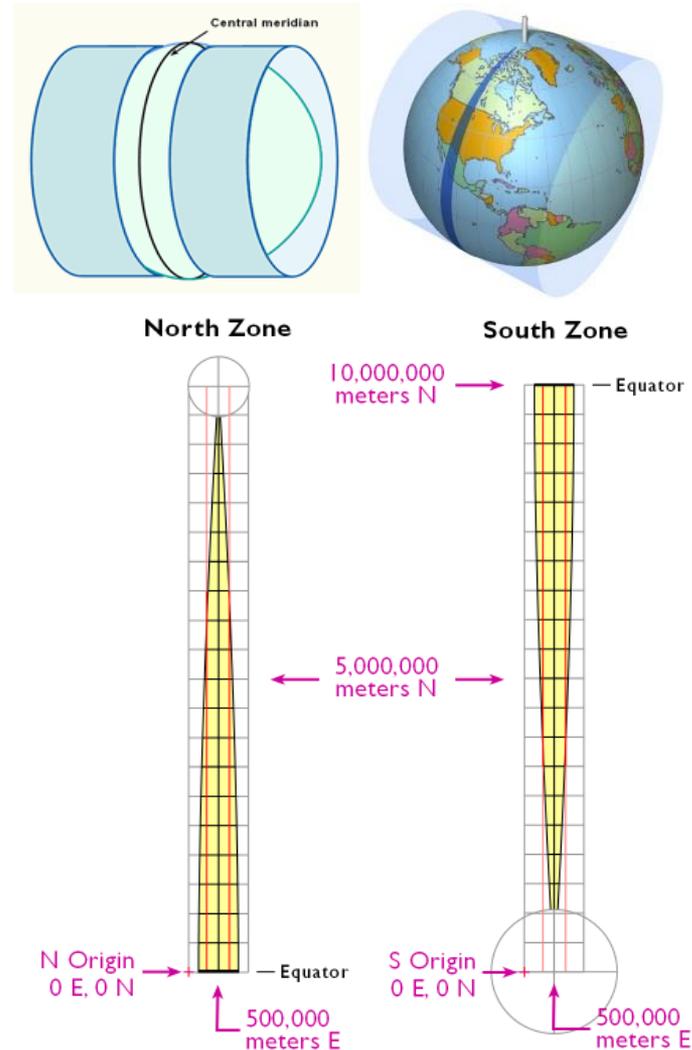


# UTM

(Universal Transverse of Mercator Projection)

The UTM system is composed of projections over a secant transverse cylinder.

Rotating the cylinder around the polar axis at intervals of  $6^\circ$ , the projection of the Earth is divided into 60 zones.



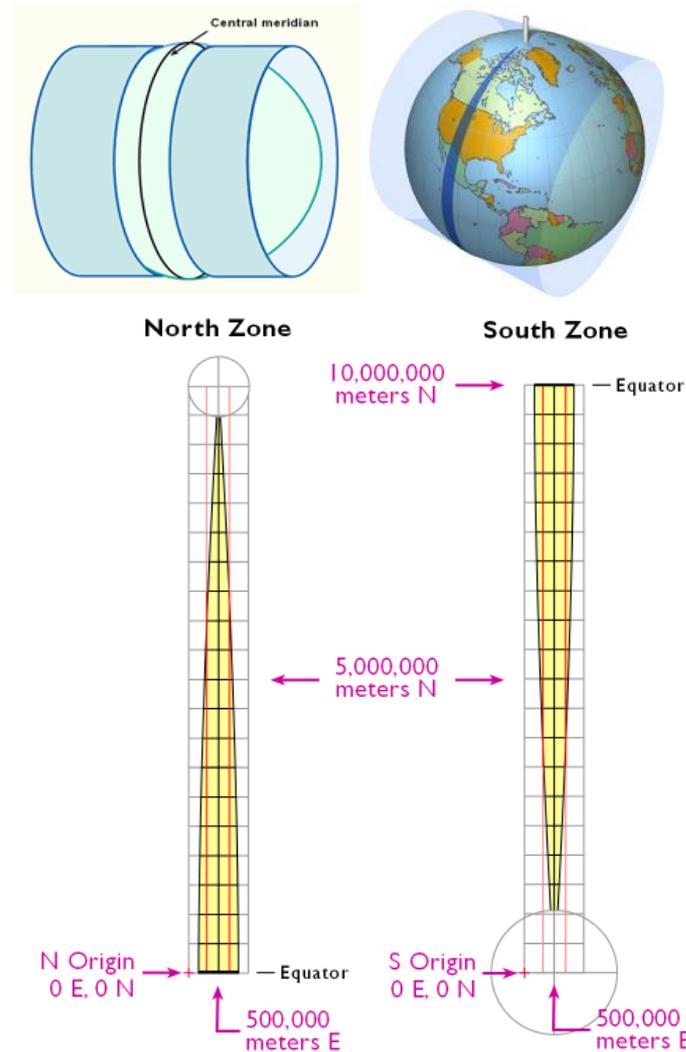
# UTM

(Universal Transverse of Mercator Projection)

The deformation is zero on lines of intersection with Earth.

The greater the distance between the standard lines and a point P, the higher the deformation

Scale factor of 0.9996 along the central meridian, where the deformation is virtually zero (0.0004)



# UTM

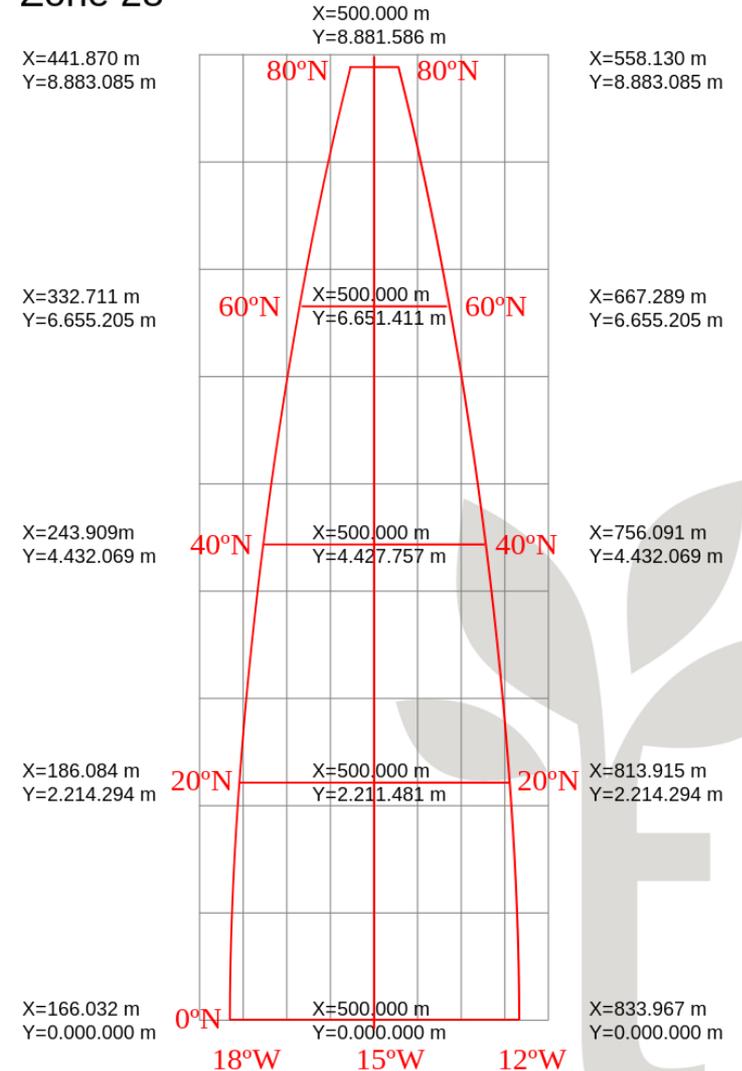
(Universal Transverse of Mercator Projection)

The coordinates are always positive and usually expressed in meters.

In North hemisphere the origin is located in equator, and 500 000 meters west of central meridian (X offset is 500 000 and Y offset is 0)

Zone 28

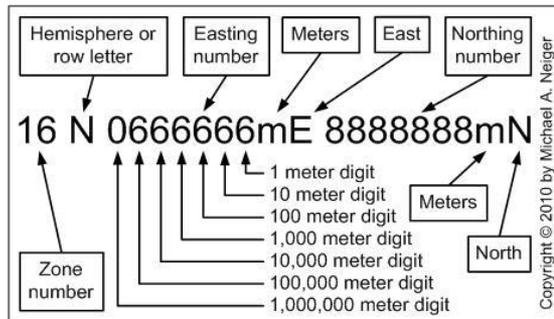
WGS84 ellipsoid



# UTM

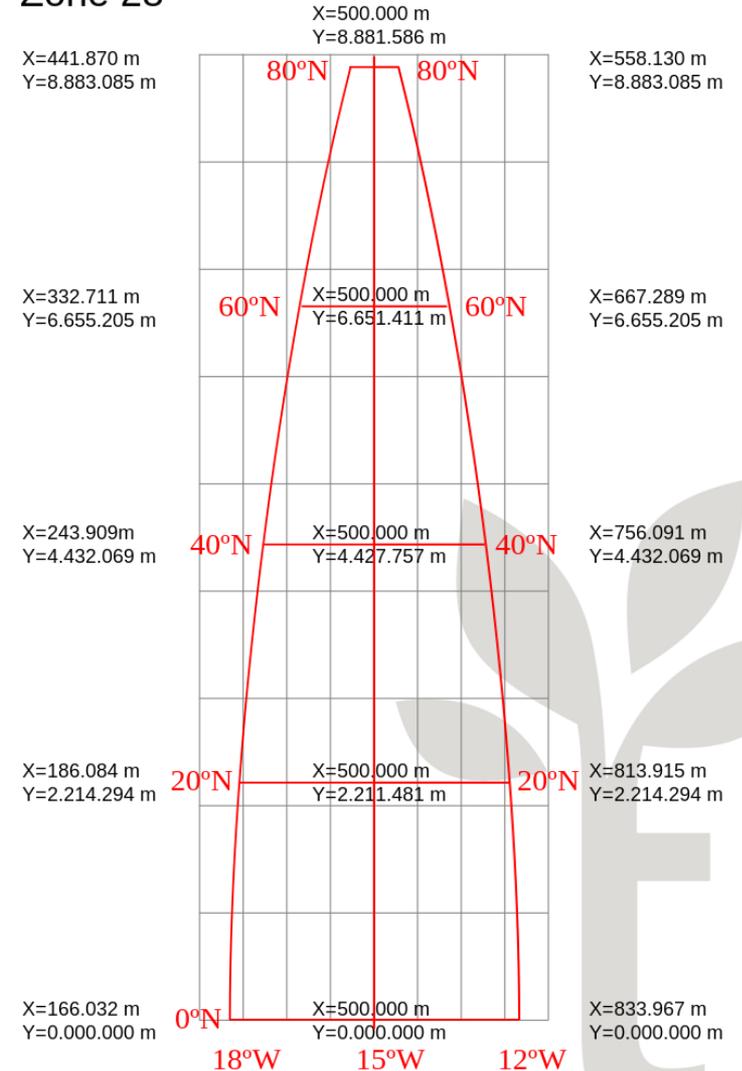
(Universal Transverse of Mercator Projection)

In South hemisphere the origin is located 10 million meters south of equator and 500 000 meters west of central meridian, X offset is 500 000 and Y offset is  $1e+07$  (10 million)

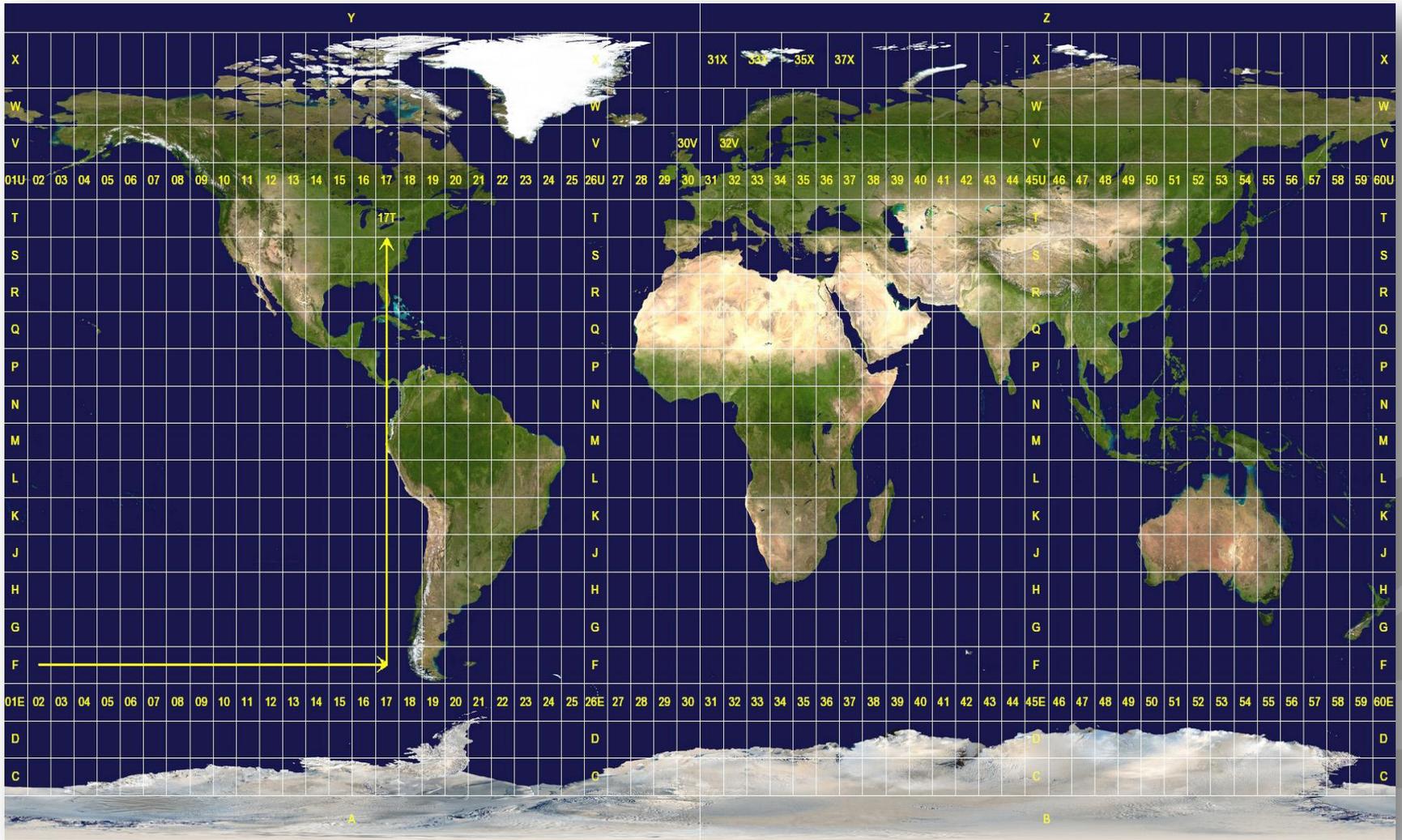


## Zone 28

WGS84 ellipsoid



# UTM Zones



Source: <http://upload.wikimedia.org/wikipedia/commons/e/ed/Utm-zones.jpg>

# Albers and Lambert Projections

The Albers and Lambert projections use two standard parallels to reduce distortions.

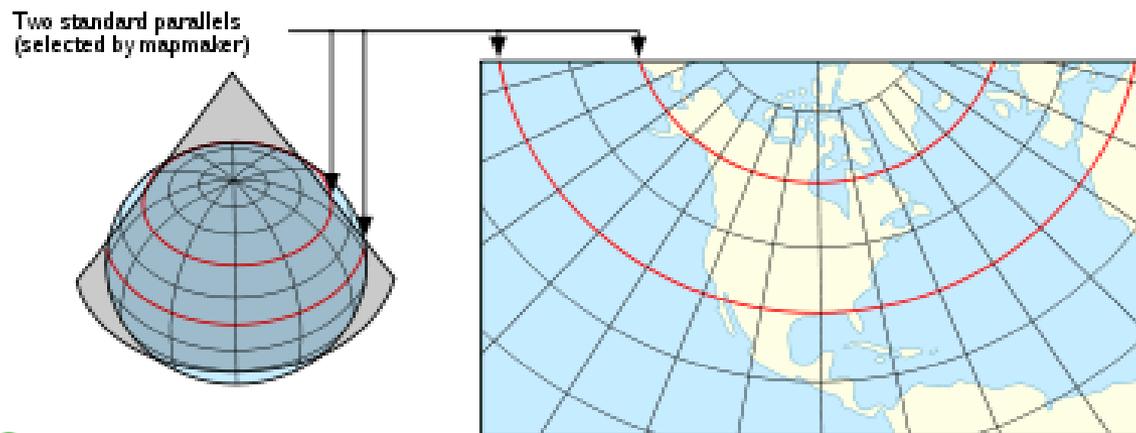
**Albers:** projection is suitable for area measurements.

**Lambert:** projection is appropriate for the shape preservation.

Such equivalent conical projections have the following characteristics:

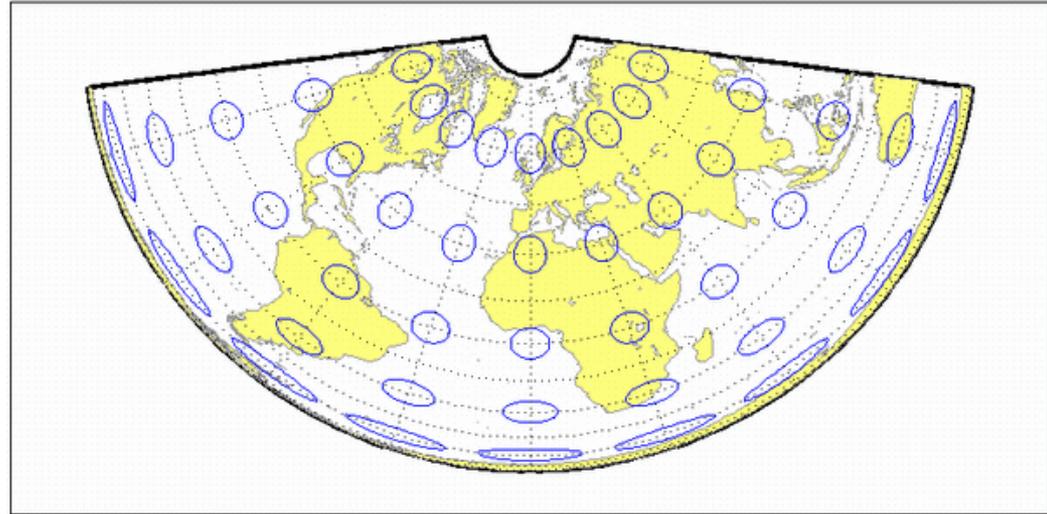
**Meridians:** equidistant straight lines converging at one point;

**Parallels:** circle arcs converging at one point. The distance between the parallel decreases as one moves away from the central parallel.

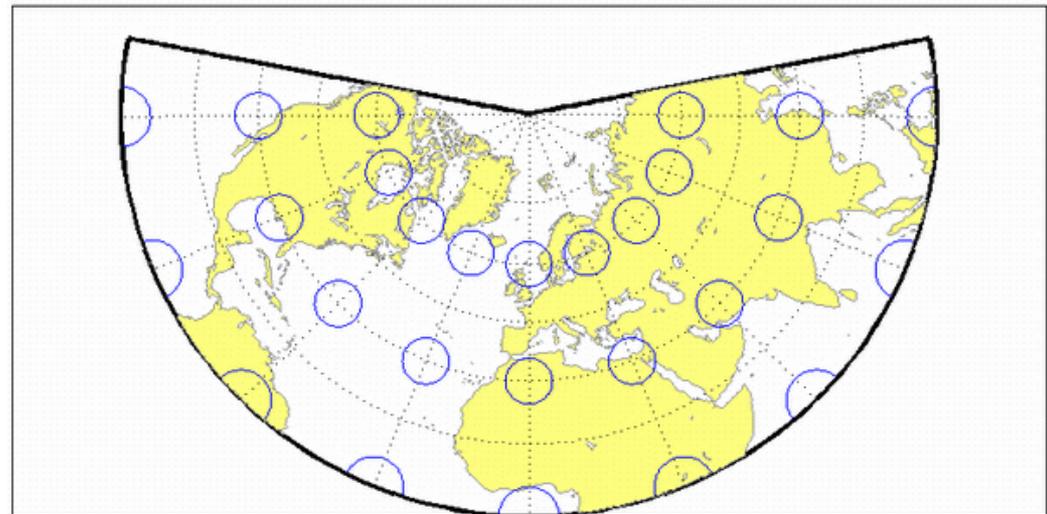


# Albers and Lambert Projections

Albers



Lambert



# Scale

It is the relationship between the size of an object (or distance) in the map and its real size .

Numeric

$$E = d / D$$

*d: distance on map*

*D: real distance*

The most common representation of numerical scales are:

$$E = 1 / 10x \text{ ou } E = 1:10x$$



# Scale

$$E = 1 / 10\ 000$$

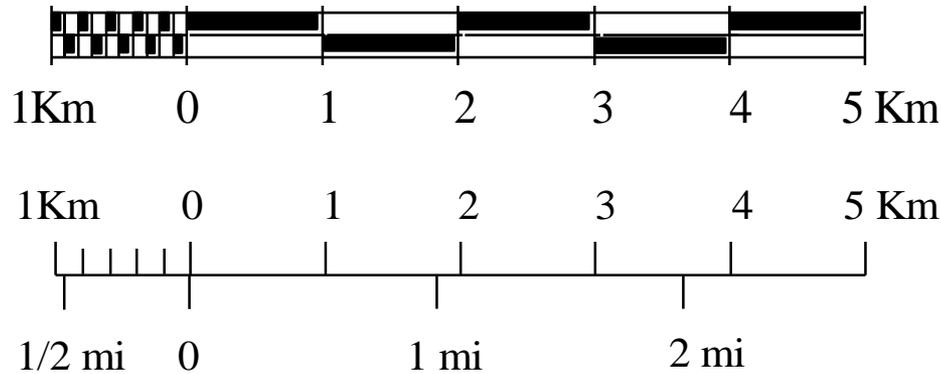
Distance = ?

$$50\ 000\ \text{cm} = 500\ \text{m}$$

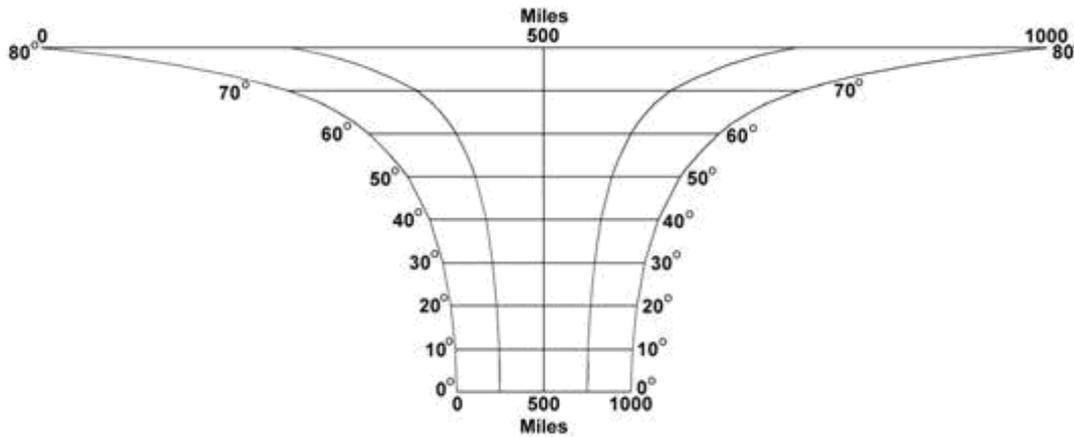


# Scale Graphic Representation

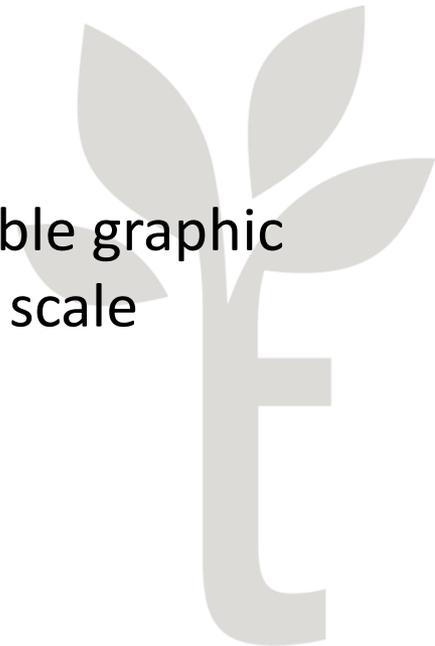
Escalas gráficas



Fixed graphic scales



Variable graphic scale



# Scale

Comparar as escalas...  $1/E$

When **E** is **smaller** we have a bigger scale which offers **more detail**

(Belem)

When **E** is **bigger** we have a smaller scale which offers **less detail**

(Earth)



# Symbolisms

Brazil is governed by Document T34-700 I and II, was recently updated by <http://www.inde.gov.br/NSDI>.

In other countries there are also regulators and exists globally ICA - <http://icaci.org/>

## ISOM 2000 ESPECIFICAÇÃO INTERNACIONAL PARA MAPAS DE ORIENTAÇÃO



**SÍMBOLOS DE ORIENTAÇÃO PEDESTRE**  
 Quadro sinótico elaborado em abril de 2011 por Prof. M.Sc. RAUL Fiedmann (FPO, UFPR & UFRR; CPOCS - Curitiba, PR, Brasil) e revisado por Prof. ZENAI László, Ph.D. (OF Council & Eötvös Loránd University - Budapeste, Hungria).

### 1. FORMAS DO TERRENO / MARRON

- 101 Curva de nível
- 102 Curva de nível mestra
- 104 Linha de declive
- 103 Linha de forma
- 340 105 Altitude (ou cota) da curva de nível
- 106 Barranco de terra
- 107 Muro de terra
- 108 Pequeno muro de terra
- 109 Vala erodida, canal, trincheira
- 110 Pequena vala erodida, canal, trincheira
- 111 Colina (símbolos 101 a 104)
- 112 Montículo (cocoruto)
- 113 Montículo (cocoruto) alongado.
- 114 Depressão (símbolos 101 a 104)
- 115 Pequena depressão
- 116 Buraco
- 117 Terreno quebrado, irregular (grande densidade de montículos e buracos)
- 118 Feição especial relacionada ao relevo (significado na legenda do mapa)

### 2. ROCHAS E PEDRAS / PRETO E CINZA

- 201 Despenhadeiro intransponível
- 202 Pilares de rocha / grandes rochedos
- 203 Face rochosa transponível
- 204 Buraco rochoso
- 205 Caverna / gruta
- 206 Pedra
- 207 Pedra grande
- 208 Área de pedras
- 209 Grupo de pedras
- 210 Terreno pedregoso
- 211 Terreno aberto arenoso
- 212 Rocha nua / afloramento rochoso

### 3. ÁGUAS E CHARCOS / AZUL

- 301 Lago
- 302 Pequeno lago
- 303 Buraco com água
- 304 Rio intransponível (a linha marginal preta é interrompida nos vaus)
- 305 Curso d'água transponível
- 306 Pequeno curso d'água transponível
- 307 Curso d'água intermitente / drenagem
- 308 Charco estreito
- 309 Charco intransponível
- 310 Charco
- 311 Charco indistinto ou sazonal
- 312 Poço ou dispositivos de captação
- 313 Nascente
- 314 Feição especial relacionada à água (significado na legenda do mapa)

### 4. VEGETAÇÃO / AMARELO, BRANCO, VERDE + PRETO

- 401 Área aberta
- 402 Área aberta com árvores esparsas
- 403 Área semiaberta
- 404 Área semiaberta com árvores esparsas
- 405 Floresta de corrida livre (de 80 a 100% da velocidade normal)
- 406 Floresta de corrida lenta (60 a 80%)
- 407 Vegetação rasteira de corrida lenta
- 408 Floresta de corrida difícil (20 a 60%)
- 409 Vegetação rasteira de corrida difícil
- 410 Vegetação de corrida muito difícil ou intransponível (0 a 20%)
- 411 Floresta com progressão direcionada (as faixas brancas indicam a direção)
- 412 Pomar
- 413 Vinhedo ou cultivo suspenso
- 414 Limite distinto de cultivo (indicado pela linha preta contínua)
- 415 Área cultivada
- 416 Limite distinto de vegetação (indicado pela linha preta pontilhada)
- 417 Limite indistinto de vegetação (no mundo real a transição é gradual)
- 418 Feição especial relativa à vegetação (e.g. tocos, troncos, árvores caídas)
- 419 Feição especial relativa à vegetação (e.g. árvore distintiva)
- 420 Feição especial relativa à vegetação (e.g. moita ou arbusto isolado)

### 5. FEIÇÕES FEITAS PELO HOMEM / PRETO

- 501 Autoestrada
- 502 Estrada principal
- 503 Estrada secundária
- 504 Estrada
- 505 Caminho de veículos
- 506 Trilha
- 507 Pequena trilha
- 508 Pequena trilha menos distinta (picada)
- 509 Acelero
- 510 Junção visível (os símbolos de estradas, caminhos ou trilhas se unem)
- 511 Junção indistinta (os símbolos das vias não se unem)
- 512 Ponte para pedestres / pinguela
- 513 Ponto de passagem com ponte
- 514 Ponto de passagem sem ponte
- 515 Ferrovia
- 516 Linha de transmissão
- 517 Linha de distribuição
- 518 Túnel

- 519 Muro de pedras
- 520 Muro de pedras em ruínas
- 521 Muro de pedras alto
- 522 Cerca
- 523 Cerca em ruínas
- 524 Cerca alta
- 525 Ponto de passagem
- 526 Edificação
- 527 Assentamento (área privada)
- 528 Área permanentemente fora dos limites (área proibida)
- 529 Área pavimentada
- 530 Ruína
- 531 Estante de tiro / linha de tiro
- 532 Sepultura
- 533 Duto transponível
- 534 Duto intransponível
- 535 Torre alta
- 536 Torre baixa
- 537 Marco / monumento
- 538 Manjedoura / cocho
- 539 Feição especial feita pelo homem (significado na legenda do mapa)
- 540 Feição especial feita pelo homem (significado na legenda do mapa)

### 6. SÍMBOLOS TÉCNICOS / PRETO E AZUL

- 601 Linhas de norte magnético
- 602 Marca de registro (de impressão)
- 603 Ponto cotado

### 7. SÍMBOLOS DE PERCURSO / PÚRPURA (MAGENTA)

- 701 Partida
- 702 Controle
- 703 Número do controle
- 704 Linha
- 705 Percurso balizado
- 706 Chegada
- 707 Limite intransponível
- 708 Ponto de passagem
- 709 Área fora dos limites
- 710 Área perigosa
- 711 Rota proibida
- 712 Posto de primeiros socorros
- 713 Ponto de refresco

[www.orientacao.esp.br](http://www.orientacao.esp.br)



# More info on reference systems and projections:

- <http://spatialreference.org/>
- <http://egsc.usgs.gov/isb/pubs/Mapprojeções/projeções.html>
- <http://plone.itc.nl/geometrics/Map%20projeções/body.htm>
- <http://pubs.er.usgs.gov/publication/pp1395>
- <http://www.giss.nasa.gov/tools/gprojector/>
- <https://trac.osgeo.org/proj/>
- <http://www.inde.gov.br/>
- <http://icaci.org/>
- <http://www.uni-stuttgart.de/gi/geoengine/mappro/lecturenotes.pdf>



# Capacitree

CAPACITY BUILDING IN SATELLITE  
FOREST MONITORING

