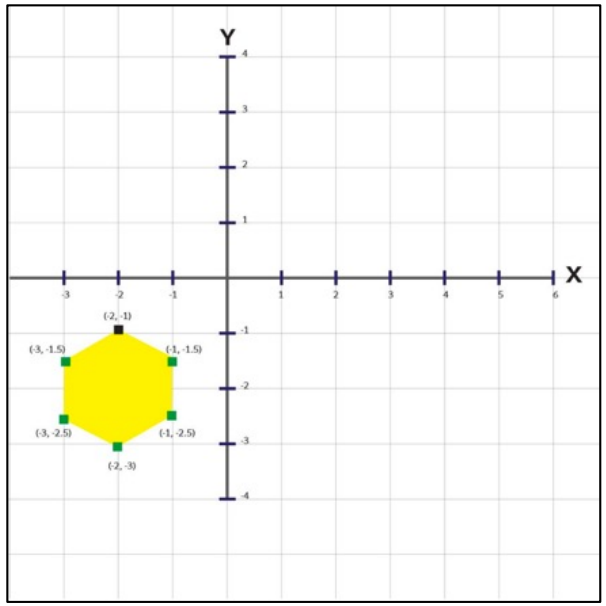
CAP-349 Spatial Databases

SPATIAL REFERENCE SYSTEMS

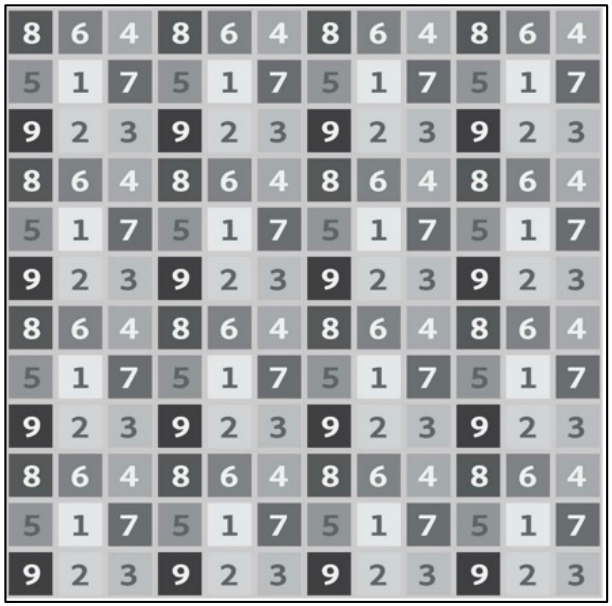
LUBIA VINHAS

Representation for geospatial data

Vector

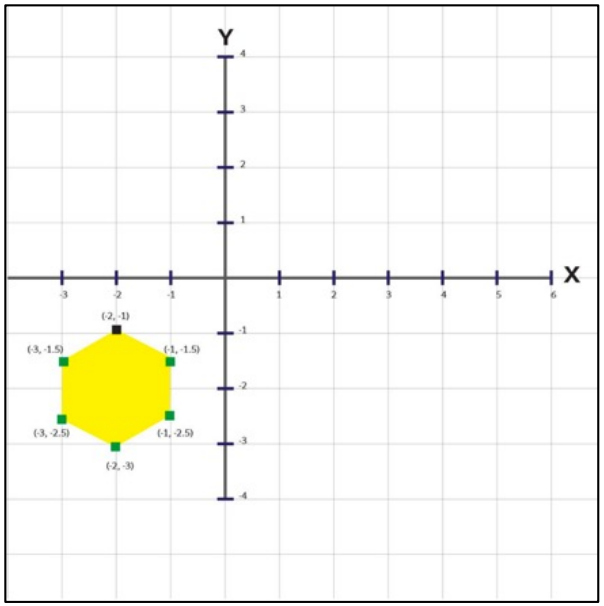


Raster

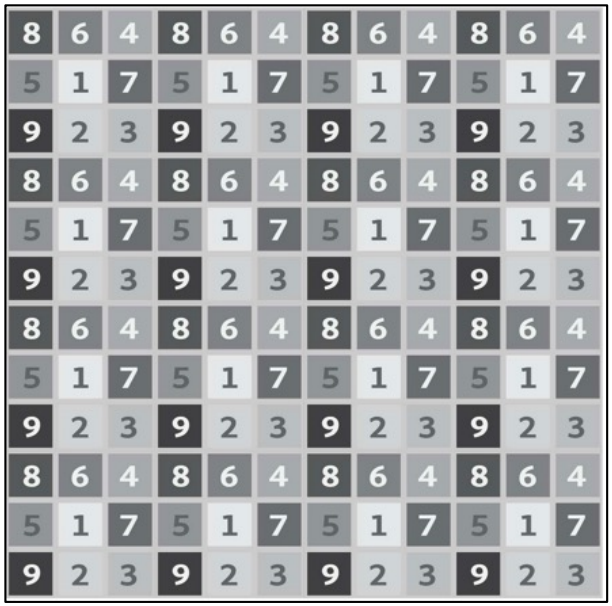


In the digital representation how to identify: the “what” and the “where”?

Vector



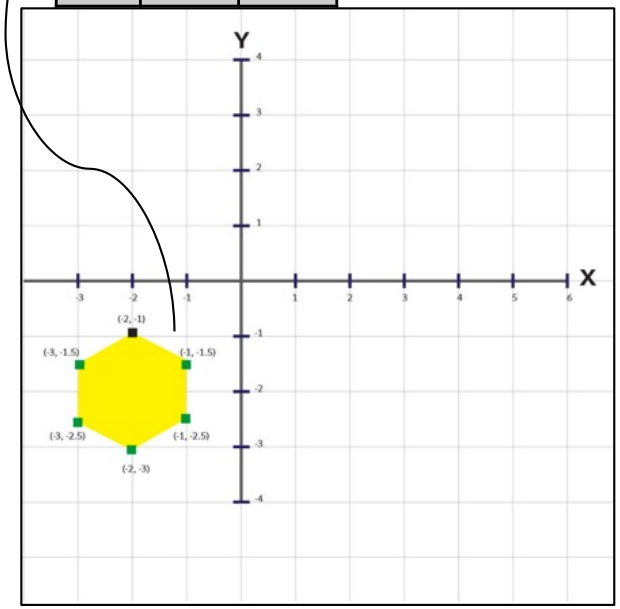
Raster



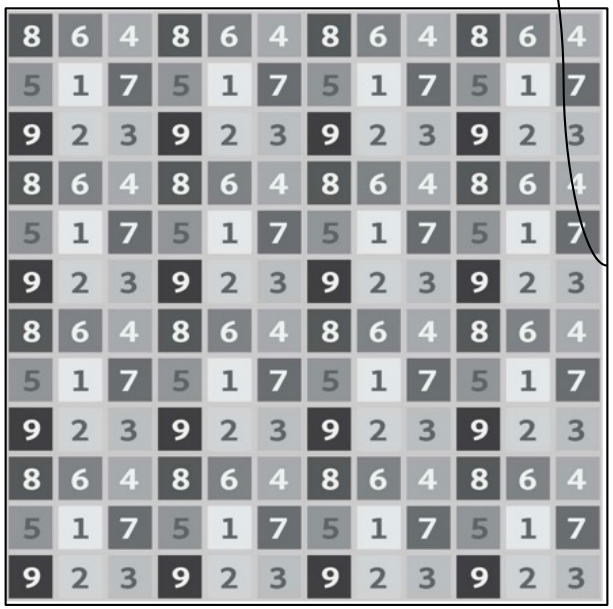
What

ID	Atr1	Atr2
o1	10.4	xxxx
o2	21.7	yyyy
o3	23.8	zzzz

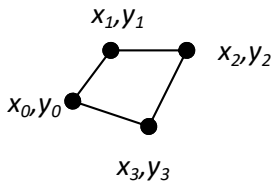
Objects defined by a set of attributes: municipalities, station, river, school...

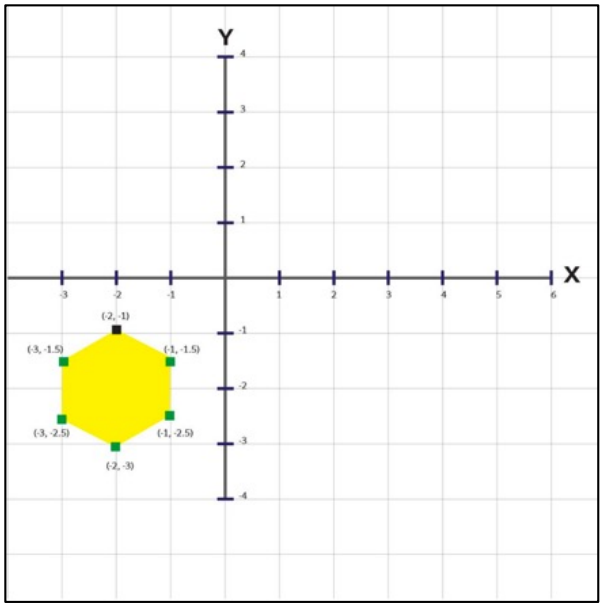


The numbers represent the value of the phenomena: altimetry, radiance, IDH, pollution, land use, ...



Where

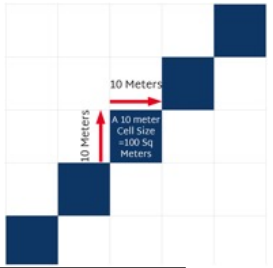


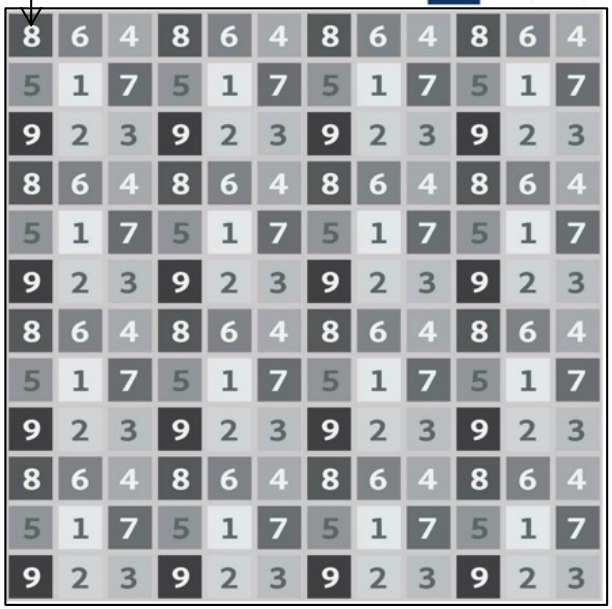


(x_0, y_0)

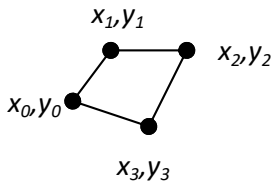
$x = x_0 + row * r_x$

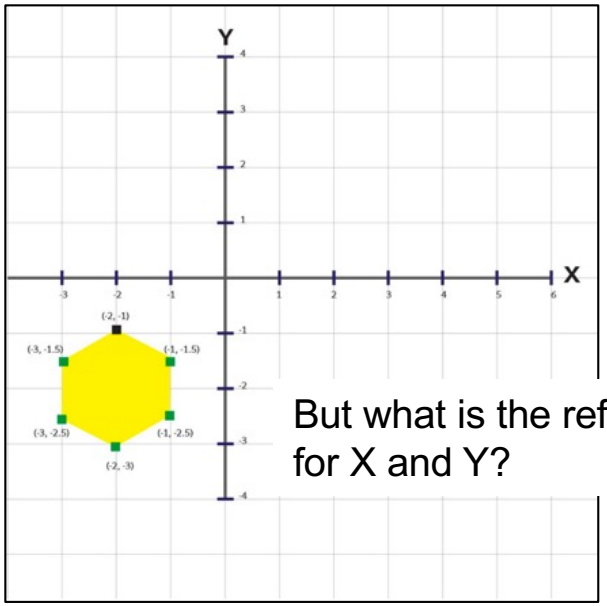
$y = y_0 + lin * r_y$





Where



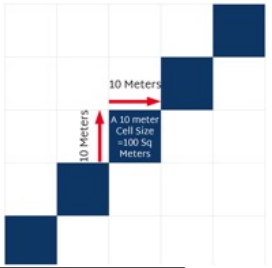


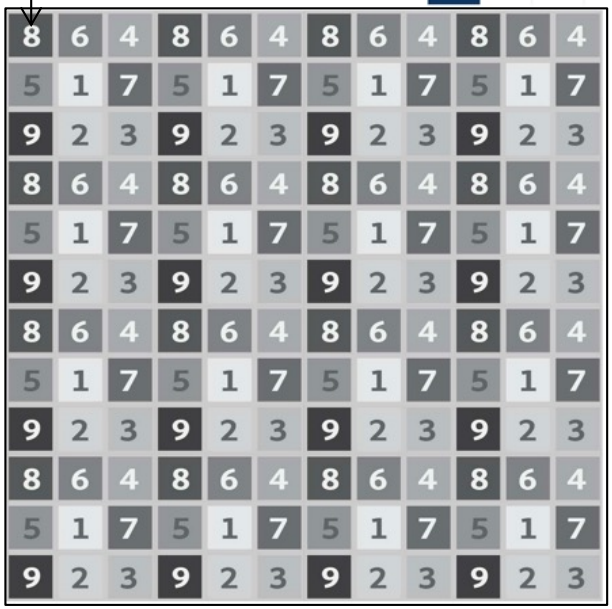
But what is the reference for X and Y?

(x_0,y_0)

$x = x_0 + row * r_x$

$y = y_0 + lin * r_y$





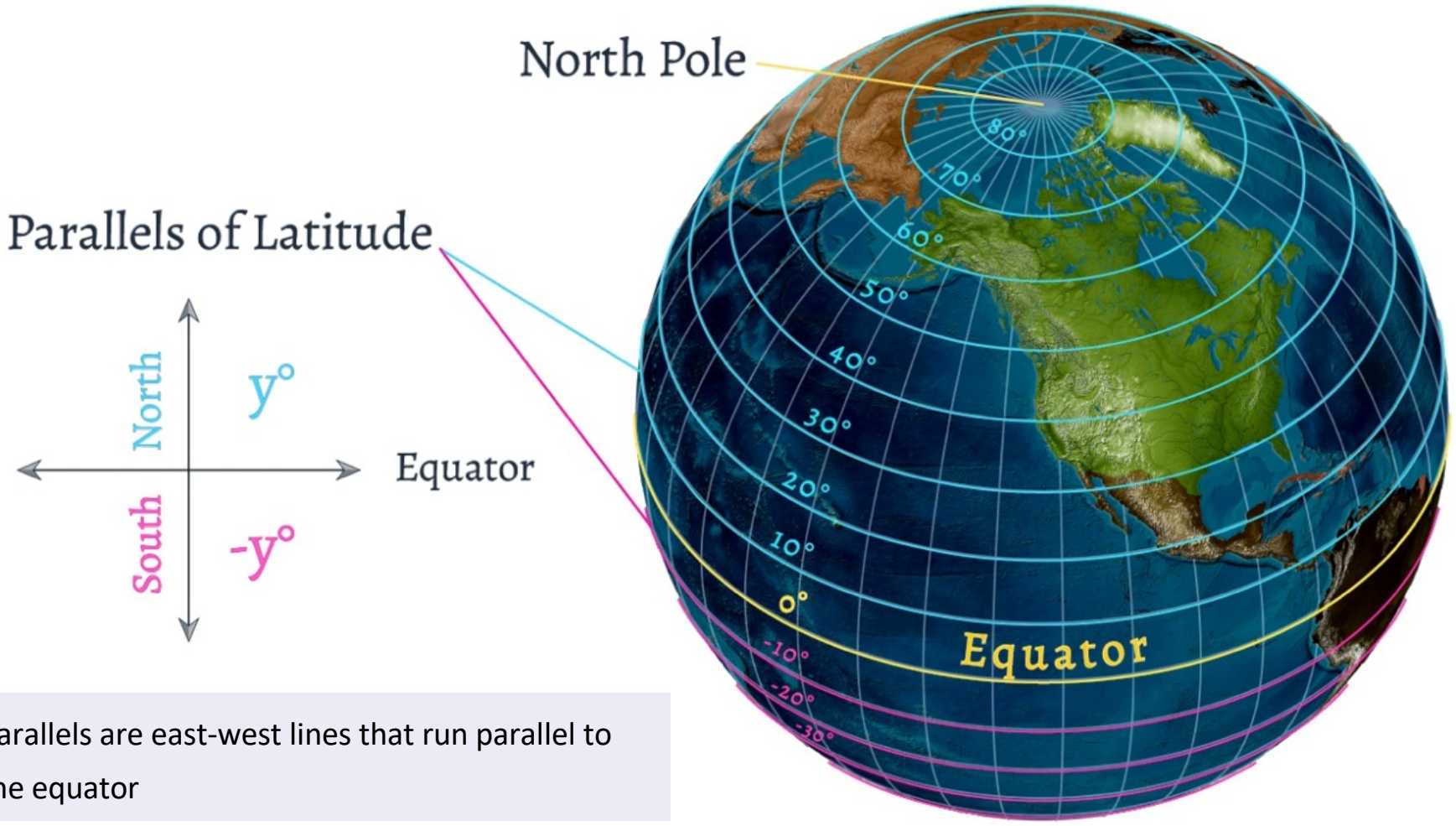
The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information. Three individuals who went on a field trip at different occasions. Using three different GPS devices, they annotate the following coordinates for the same 2 locations:

https://www.gps.gov/systems/gps/

	JANE		JOHN		BILL	
	X	**Y**	**X**	**Y**	**X**	**Y**
PA	-42.3591666667	-23.3194444444	770061.694961	7418652.21437	1189337.72907	-2627767.87227
PB	-43.0166666667	-29.5347222222	692193.800396	6731129.17863	1063065.76762	-3318803.38603

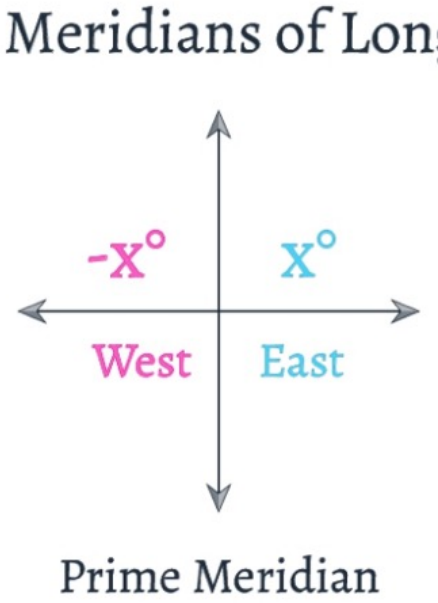
Who has determined the correct location?

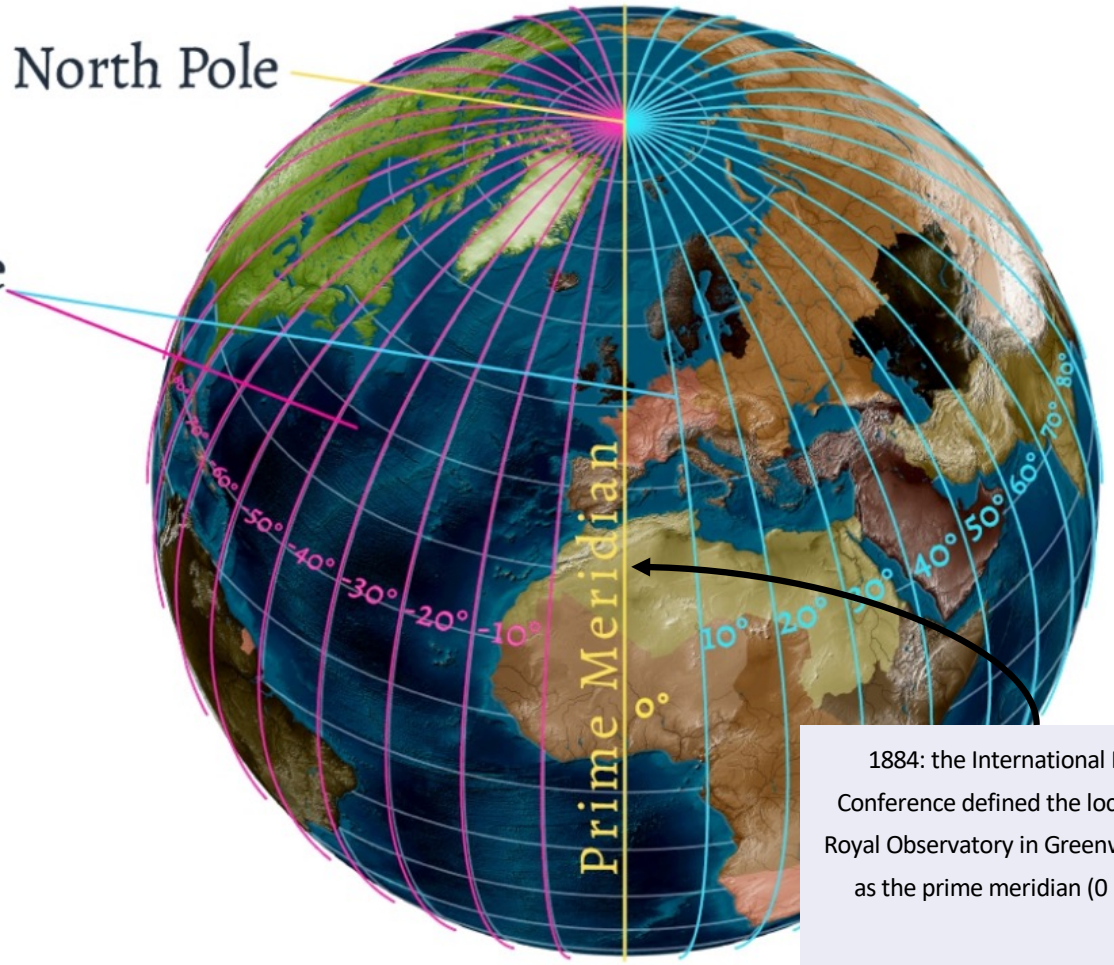
Some pictures are from : Rock, Amy & Malloy, Nicolas. (2019). Geospatial Concepts: The Fundamentals of Geospatial Science.



Parallels are east-west lines that run parallel to the equator

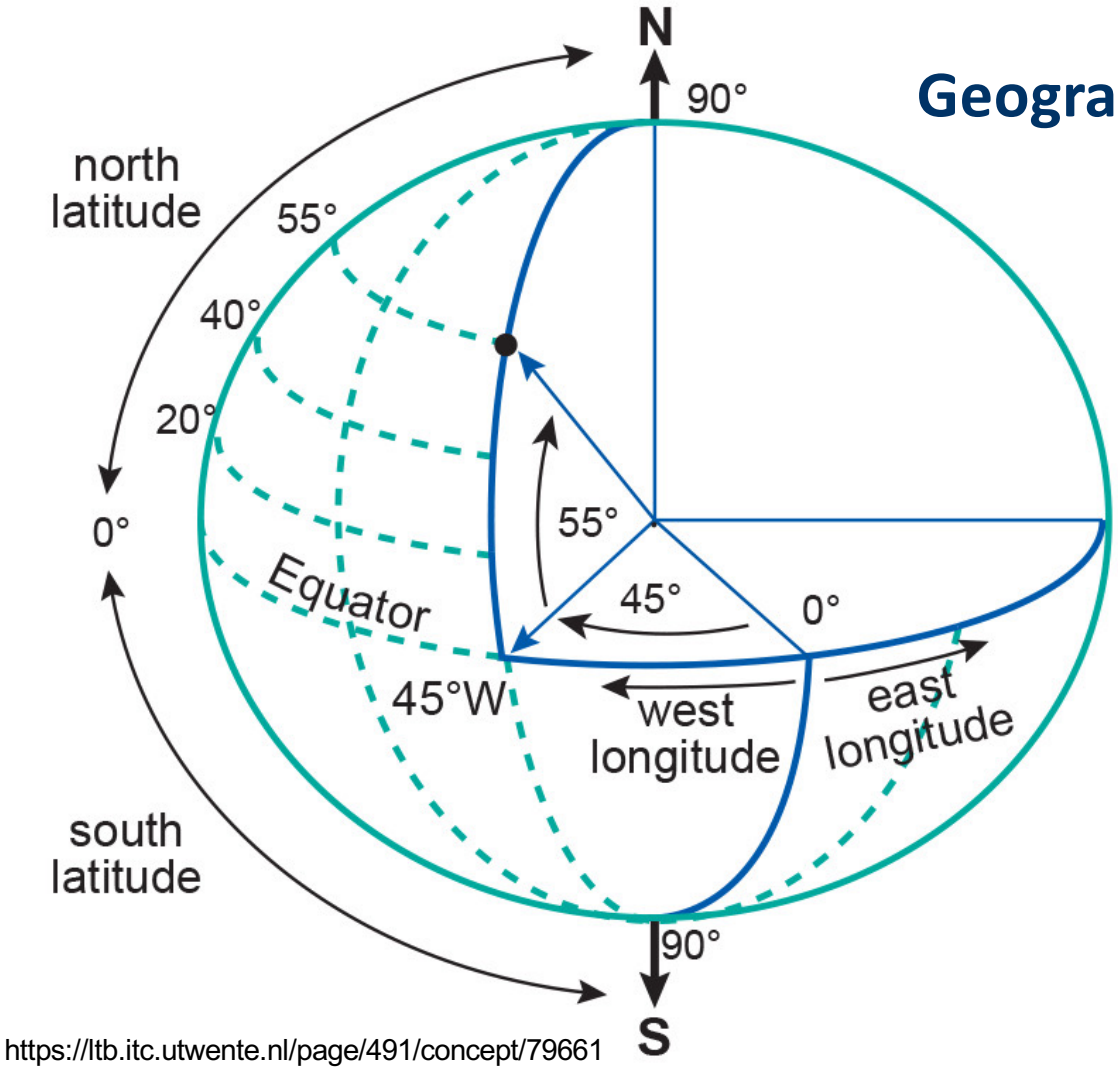
Meridians are a series of lines that run north-south passing through the poles





1884: the International Meridian Conference defined the location of the Royal Observatory in Greenwich, England as the prime meridian (0 longitude)

Geographic Coordinate System

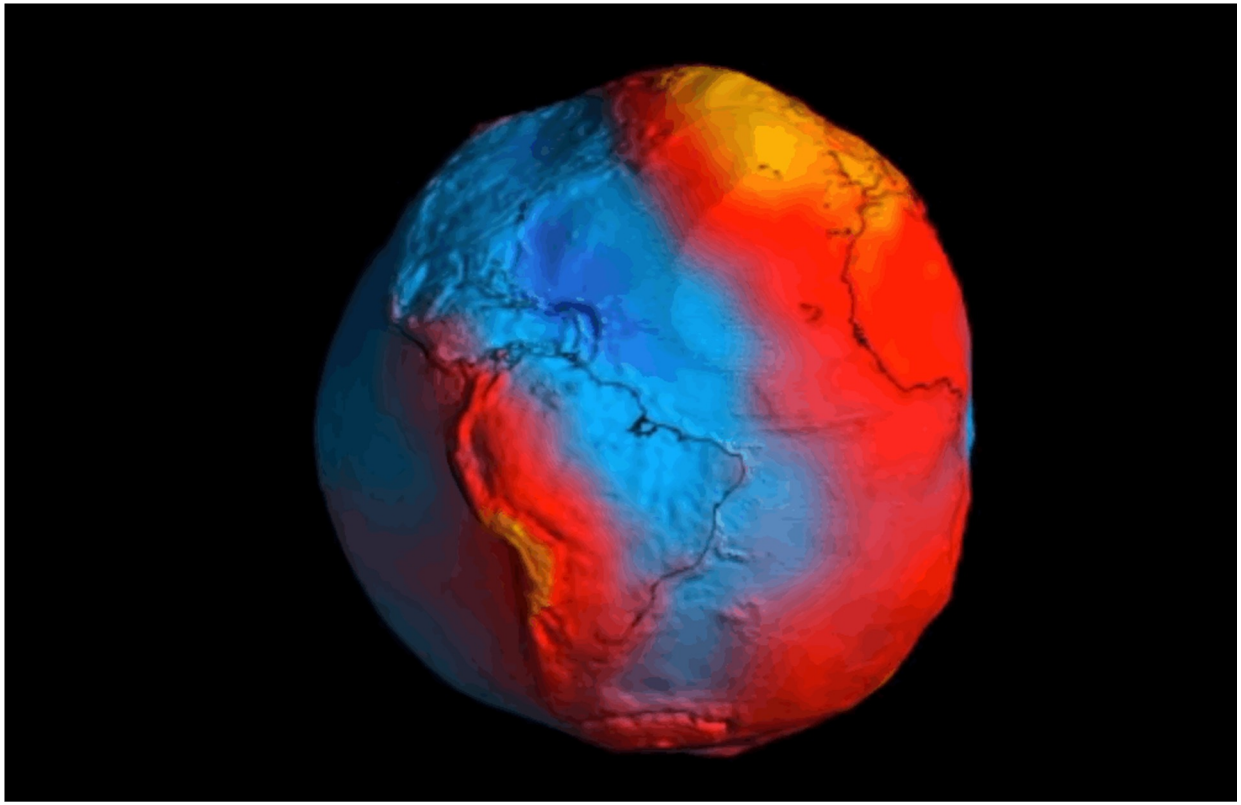


https://ltb.itc.utwente.nl/page/491/concept/79661

Composed by a set of geographic latitudes (phi or φ) and longitudes (lambda or λ), measured over a Datum, that represents the Earth Surface

Measuring Earth

Geodesy is the science of measuring and representing the size and shape of Earth, the exact position of points on Earth, and Earth's gravitational and magnetic fields as they change over time.
Pythagoras was one of the first to advocate the idea of a spherical Earth.
Newton, in the 17th century: Earth takes the shape of an oblate spheroid. Proved by field work in 1735.
Elevation: a relative measurement equal to the height above mean sea level. Accurate vertical measurements, such as elevation, required a different model of Earth called a geoid.



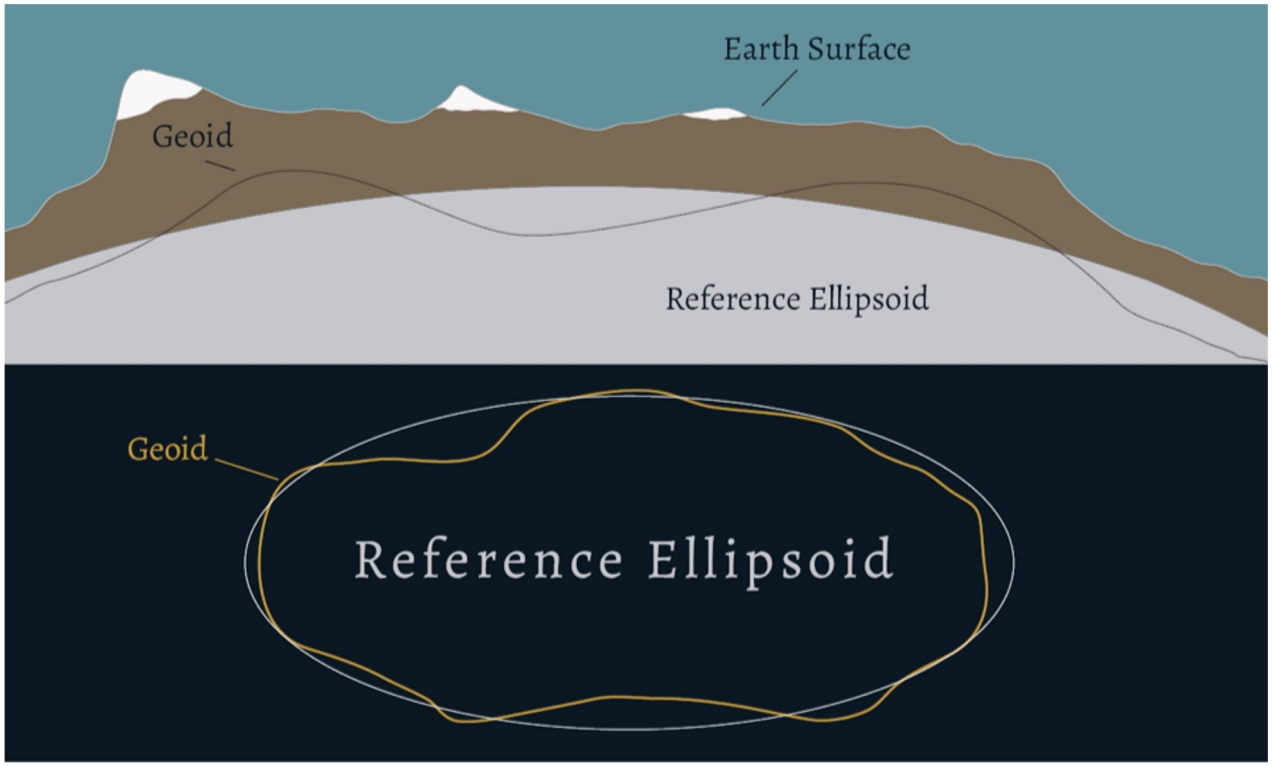
Currently, the most accurate model of the geoid is obtained with satellites such as GOCE.

GOCE: Geoid - YouTubeyoutube.com

The **Reference Ellipsoid** is a smooth, mathematically defined surface model.

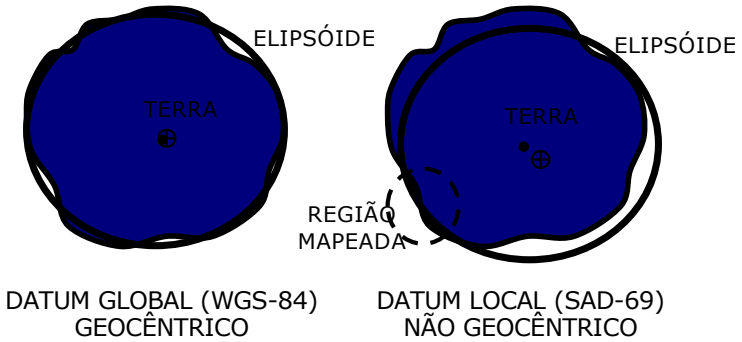
The geoid and the reference ellipsoid are not an exact match; there are multiple reference ellipsoids used today, each optimized for different regions of Earth.

Reference ellipses + surveyed control points = **geodetic datum**.



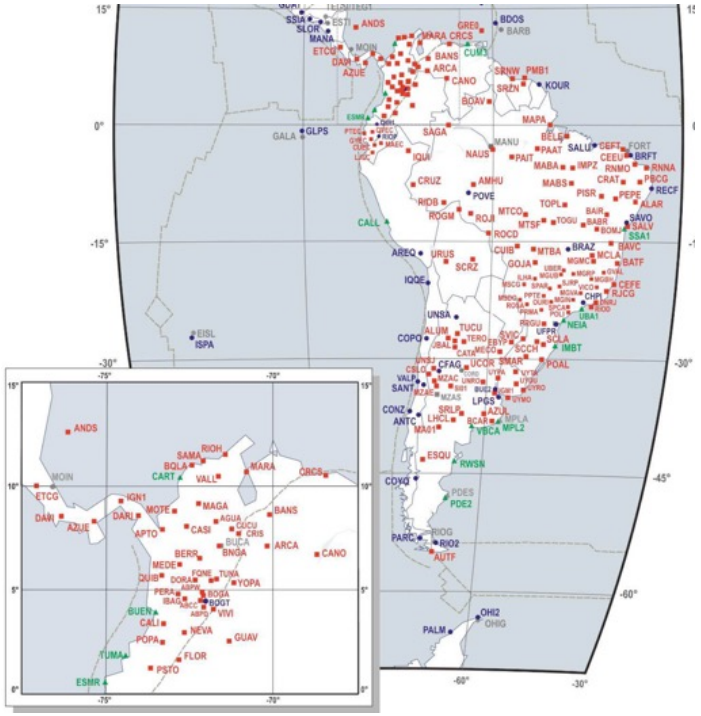
Geocentric Datum: the origin of the reference ellipsoid and the mass center of Earth coincide

Local Datum: the origin of the reference ellipsoid is in an arbitrary point



Important: the geographic coordinate system includes a Datum, the prime meridian and the units for the latitude and longitude

Desde 25 de fevereiro de 2015, o SIRGAS2000 (Sistema de Referência Geocêntrico para as Américas) é o único sistema geodésico de referência oficialmente adotado no Brasil. Entre 25 de fevereiro de 2005 e 25 de fevereiro de 2015, admitia-se o uso, além do SIRGAS2000, dos referenciais SAD 69 (South American Datum 1969) e Córrego Alegre. O emprego de outros sistemas que não possuam respaldo em lei, pode provocar inconsistências e imprecisões na combinação de diferentes bases de dados georreferenciadas.



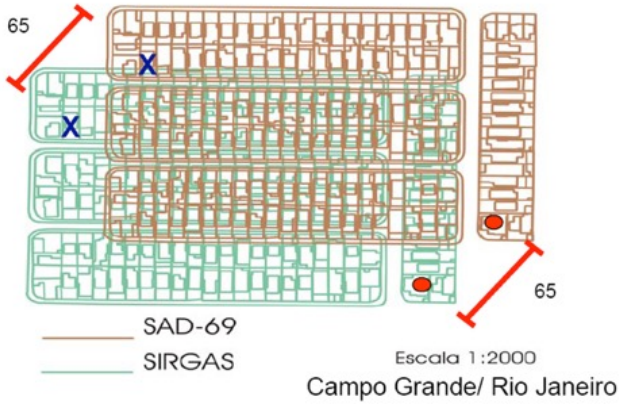
https://www.ibge.gov.br/geociencias/informacoes-sobre-posicionamento-geodesico/sirgas/16691-projeto-mudanca-do-referencial-geodesico-pmrg.html

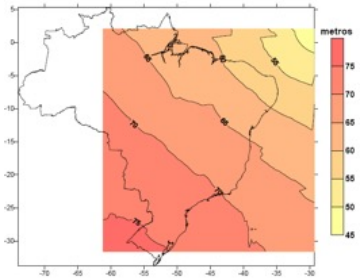
Data in geodetic coordinates, in different Datum, can generate positioning errors. For example, a mapping performed in SAD69 and another in SIRGAS2000 cannot be shown on the same map without some treatment being done.

From SIRGAS2000 to SAD69 : ~65 meter over Brazil

From SIRGAS2000 to WGS84: none

From Córrego Alegre to SAD69: <= 60 metros

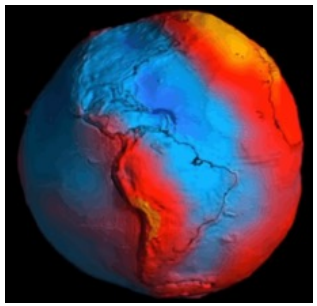




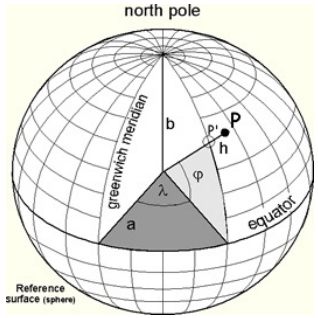
Oliveira, J. et al. *Avaliação de parâmetros de transformação regionais entre os sistemas SAD69 e SIRGAS2000*. Revista Brasileira de Geomática. 8. 363-376. 10.3895/rbgeo.v8n4.10968.

The process to generate a map

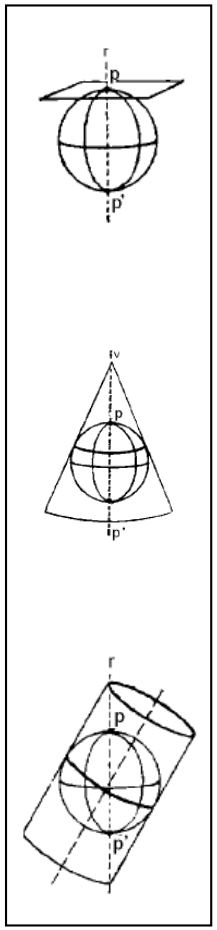
Geoid



Ellipsoid



Projection



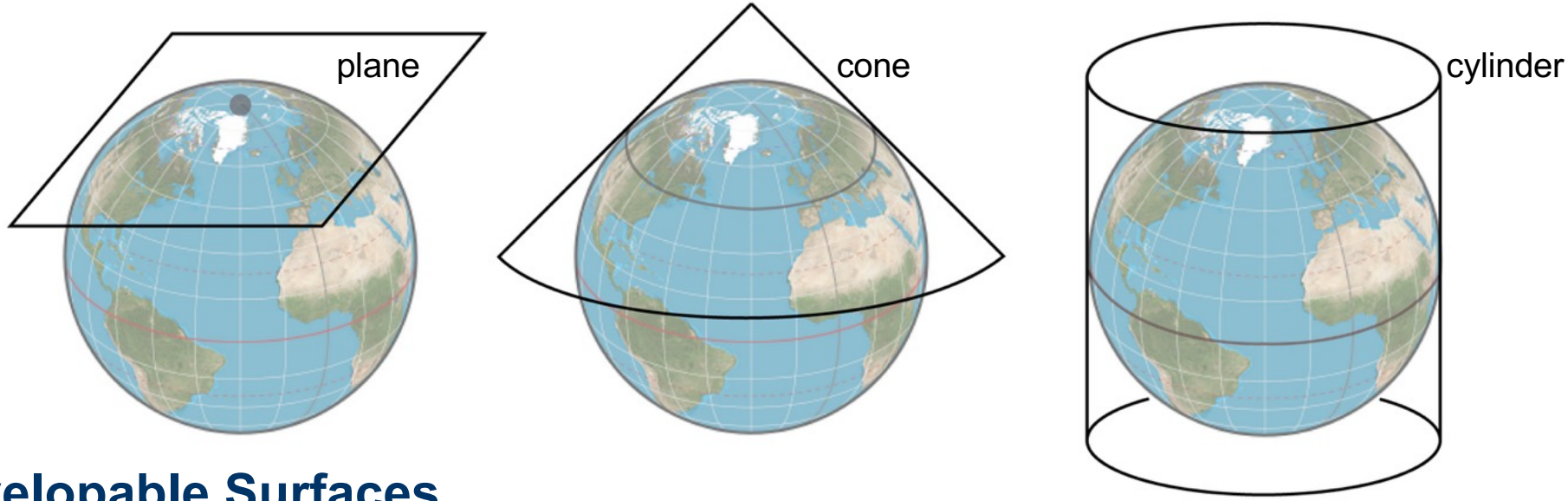
Map

A **Map Projection** is a geometric transformation of the Earth's "sphere" on a plane using mathematical equations.

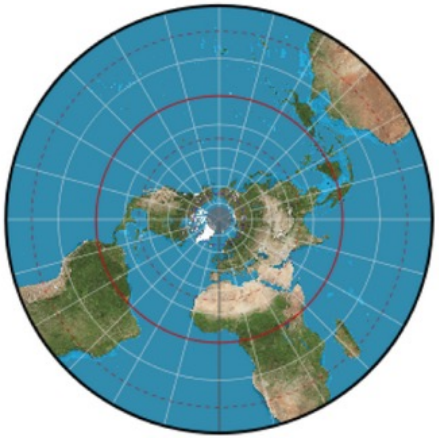
Whenever coordinates are transformed from 3-dimensional angular to 2-dimensional planar coordinates, spatial relationships are distorted, as compared to their relationships (measurements) on the Earth's surface. Either angles or areas or both must distort, as well as distances and many other kinds of measurements.

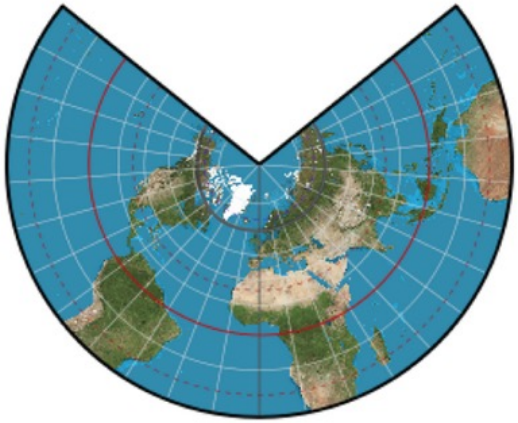
$$x = f_1(\phi,\lambda) \qquad y = f_2(\phi,\lambda)$$

$$\lambda = g_1(x,y) \qquad \phi = g_2(x,y)$$

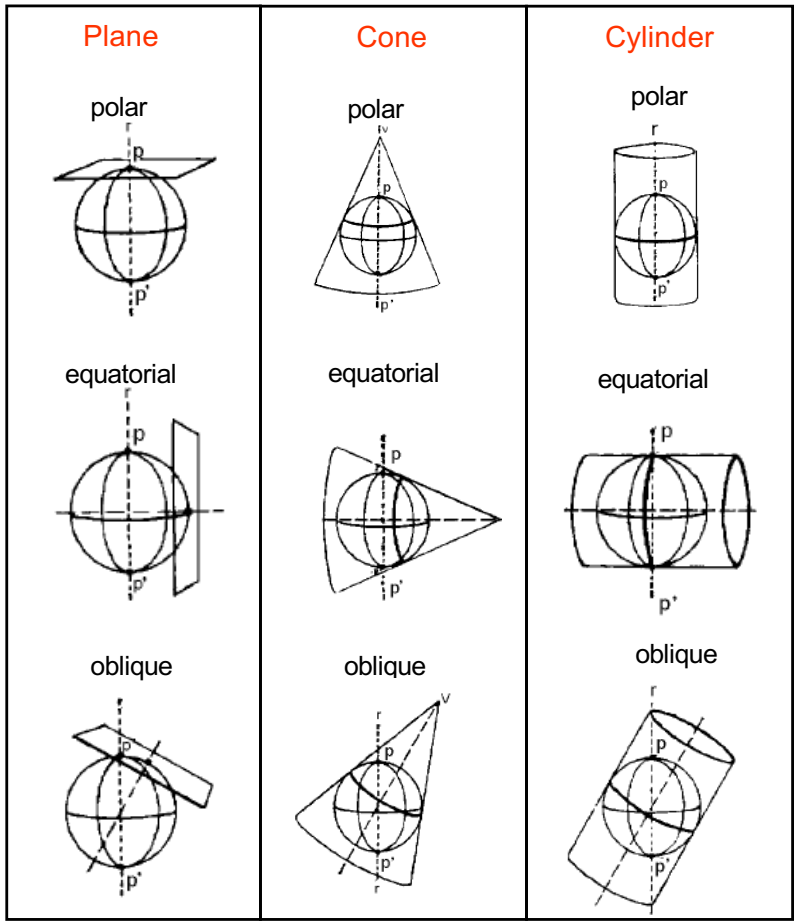


Developable Surfaces





https://gistbok.ucgis.org/bok-topics/2018-quarter-02/map-projections



Developable surface and aspect

Properties

Equidistant: preserve distances

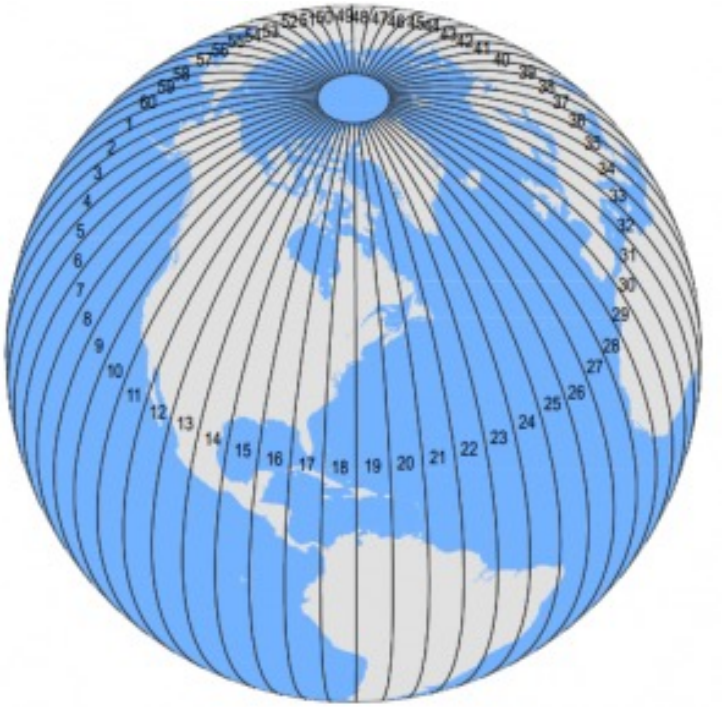
Equivalent: preserve areas

Conformal: preserve local angles

https://www.jasondavies.com/maps/transition/

https://www.icsm.gov.au/education/fundamentals-mapping/projections/commonly-used-map-projections

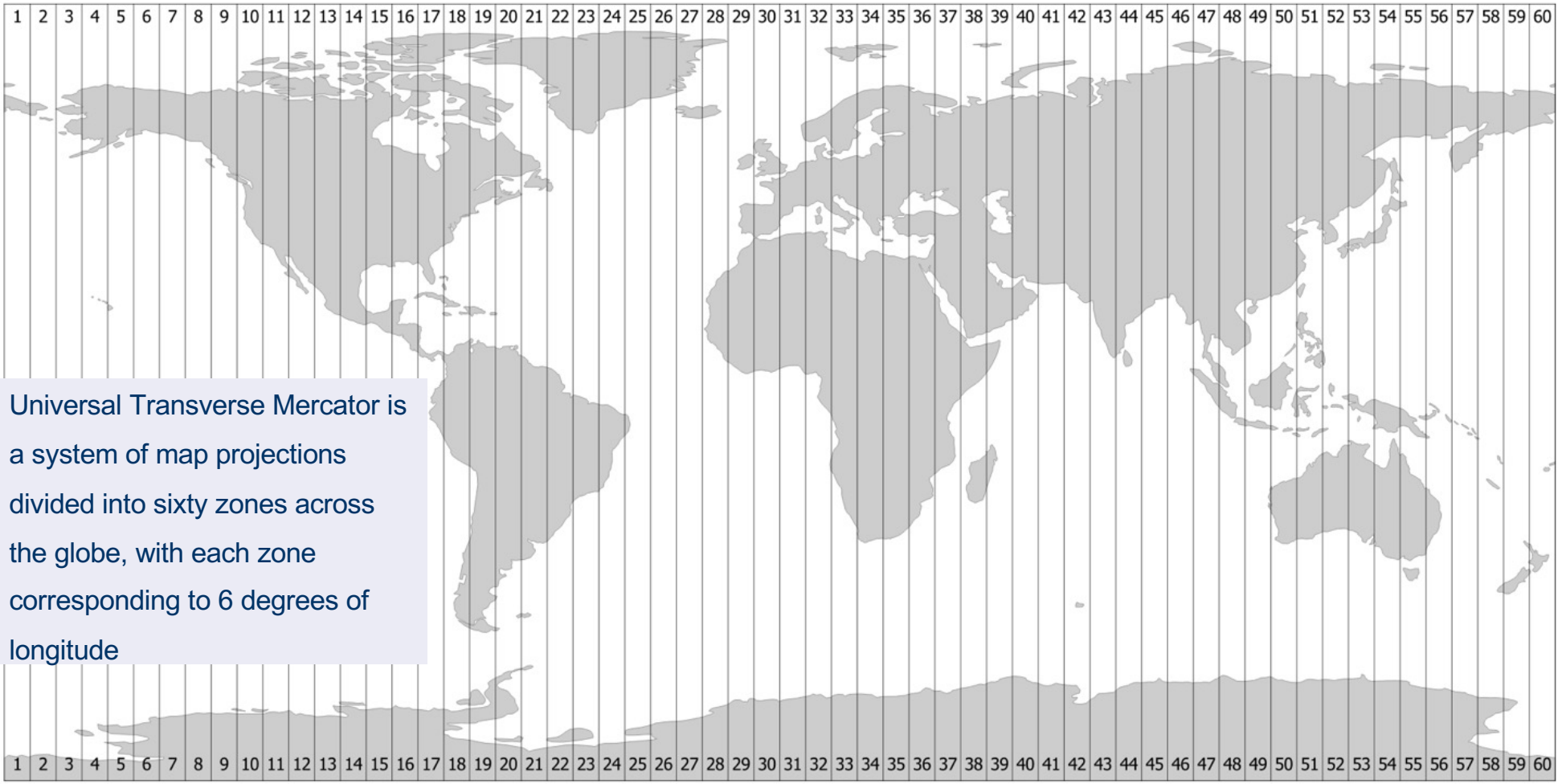
UTM - Universal Transverse Mercator



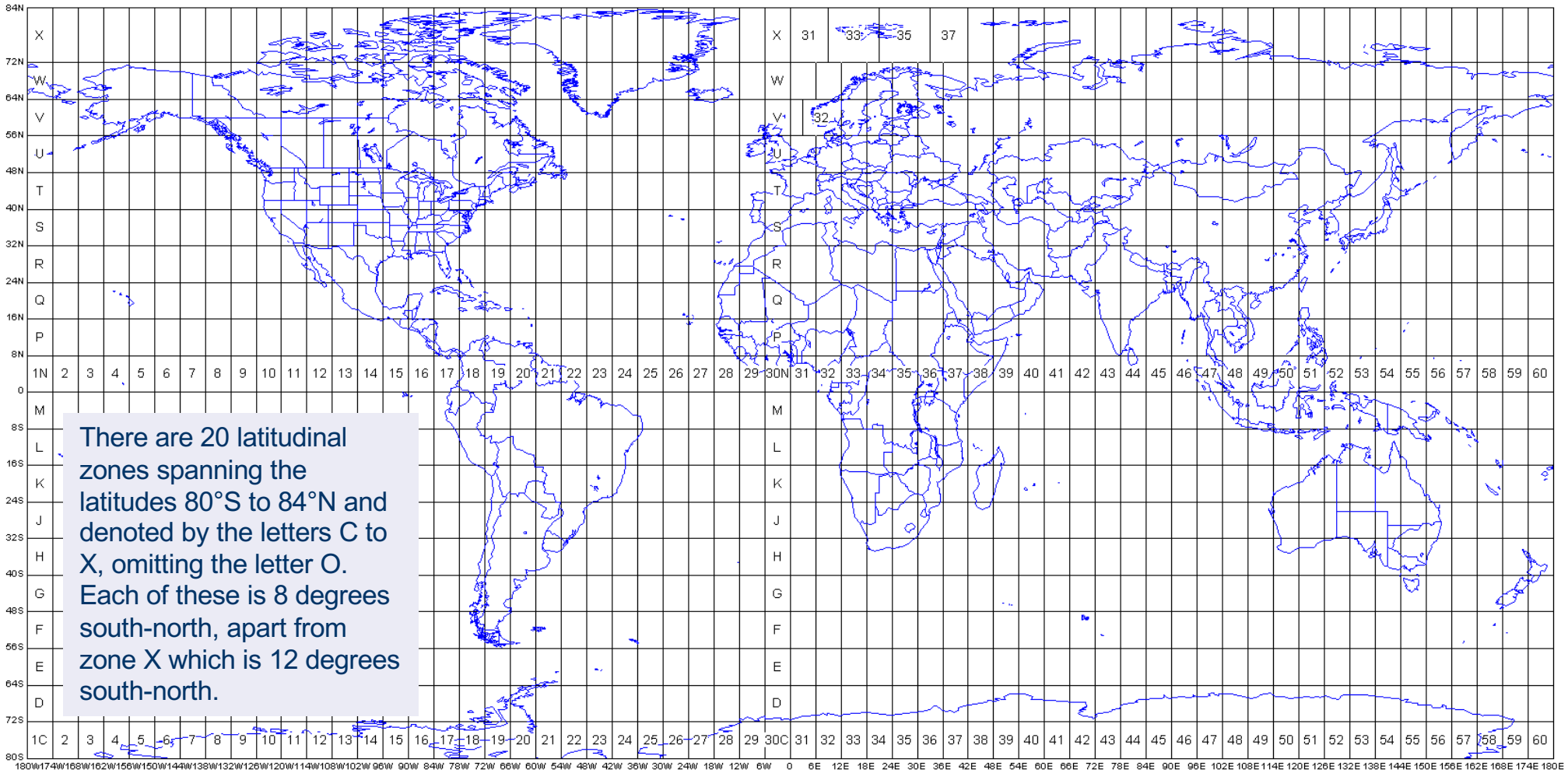
The UTM (Universal Transverse Mercator) coordinate system divides the world into sixty north-south zones, each 6 degrees of longitude wide.

UTM coordinates are easy to use, and they work with almost all GPS devices. Also, UTM covers most of the world. The system uses meters as its base unit, which makes conversions and measurements easier.

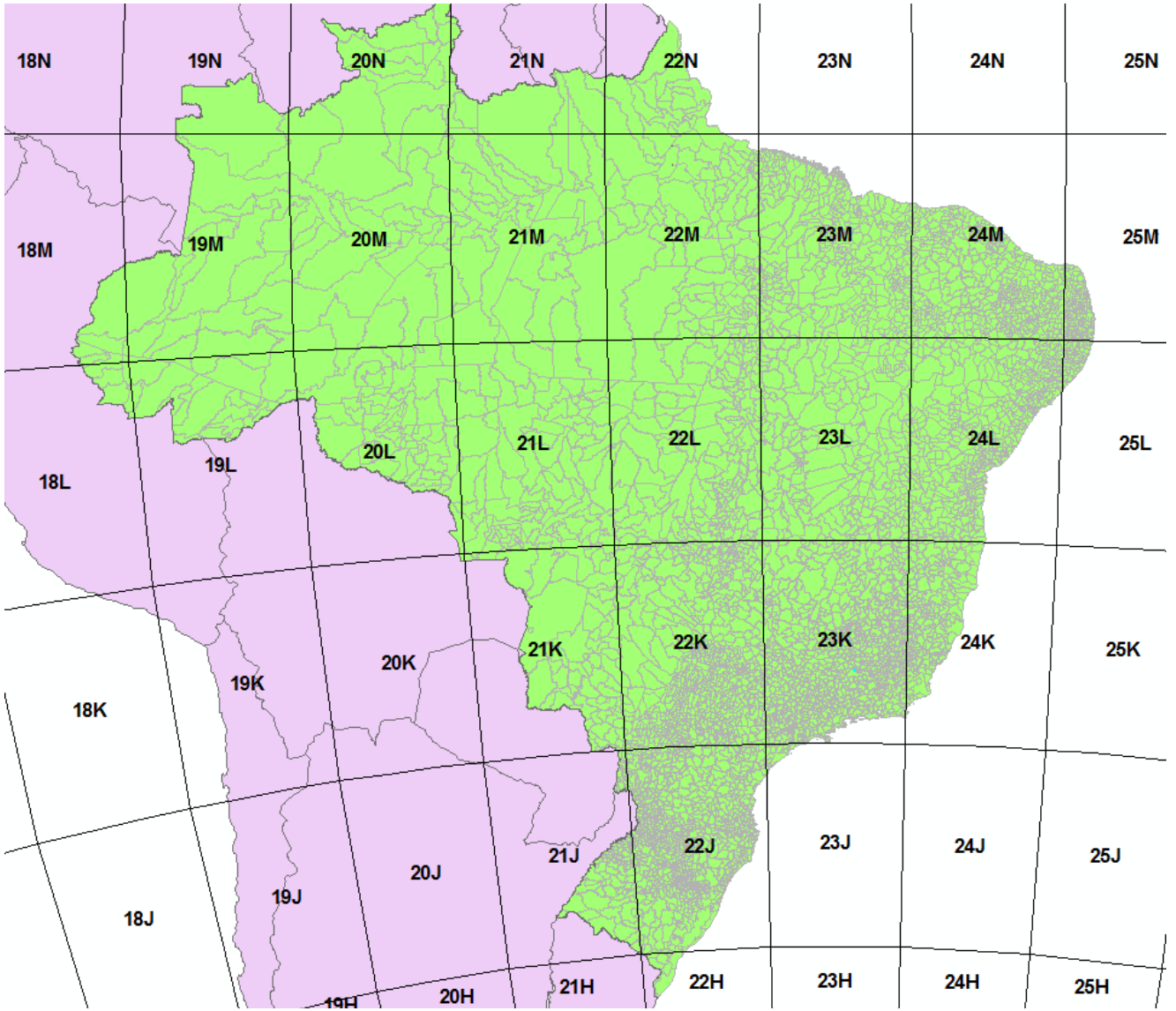
As the boundaries between the UTM zones approach, the distortion of scale increases in each UTM zone.



Universal Transverse Mercator is a system of map projections divided into sixty zones across the globe, with each zone corresponding to 6 degrees of longitude


There are 20 latitudinal zones spanning the latitudes 80°S to 84°N and denoted by the letters C to X, omitting the letter O. Each of these is 8 degrees south-north, apart from zone X which is 12 degrees south-north.

UTM Zones covering Brasil



False easting is a linear value applied to the origin of the x coordinates. **False northing** is a linear value applied to the origin of the y coordinates. False easting and northing values are usually applied to ensure that all x and y values are positive.

For the false easting and northing to work, 10,000,000 meters will be added to the ordinate axis (North-South) and 500,000 meters will be added to the abscissa axis (East-West).

https://atlasescolar.ibge.gov.br/conceitos-gerais/o-que-e-cartografia/as-projec-o-es-cartogra-ficas.html


PROJEÇÃO UNIVERSAL TRANSVERSA DE MERCATOR

ESCALA 1: 50 000

1 000 m 0 1 000 2 000 3 000 m

Equidistância das curvas de nível: 20 metros

Origem da quilometragem: Equador e Meridiano 45° W. Gr. acrescidas as constantes 10 000 km e 500 km respectivamente

Datum vertical: marégrafo Imbituba, SC

Datum horizontal: Córrego Alegre, MG

Levantamento estereofotogramétrico topográfico regular

Aerofotografias - 1966; apoio suplementar e reambulação executados em 1971 pelo Departamento de Geodésia e Topografia; restituição, aerotriangulação e preparo para a impressão realizados pelo Departamento de Cartografia

Esta folha foi preparada e impressa em decorrência do Convênio entre o IBGE e o Instituto de Geociências Aplicadas do Conselho Estadual do Desenvolvimento de Minas Gerais

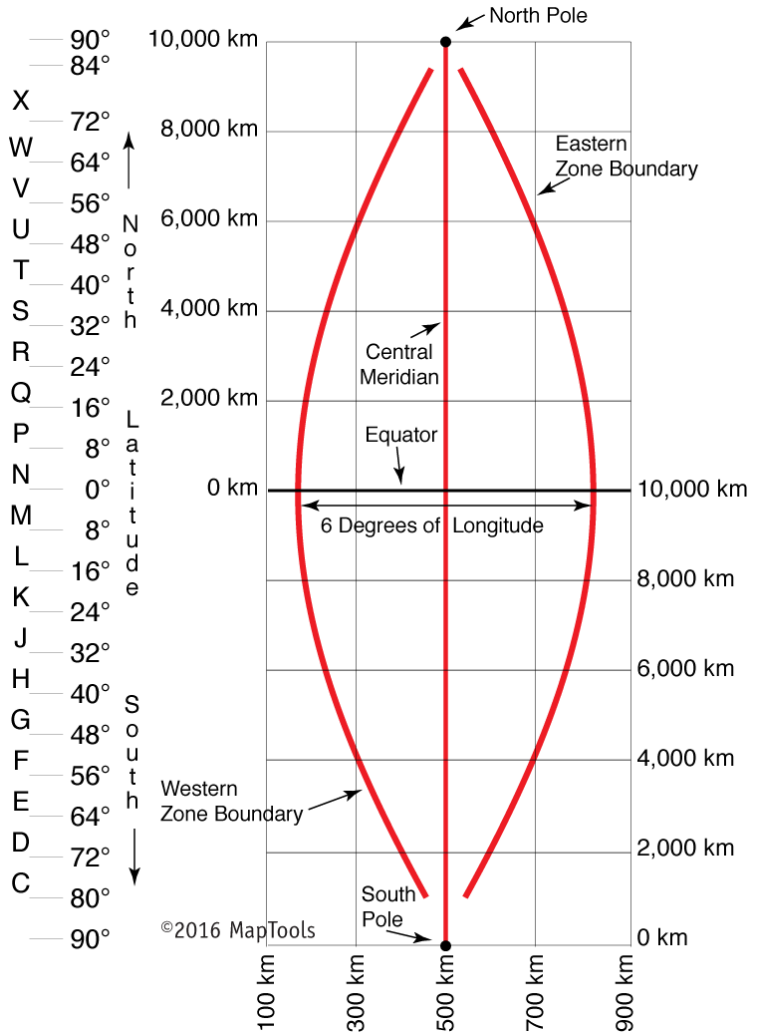
SUPERINTENDÊNCIA DE CARTOGRAFIA

PRIMEIRA EDIÇÃO — 1974

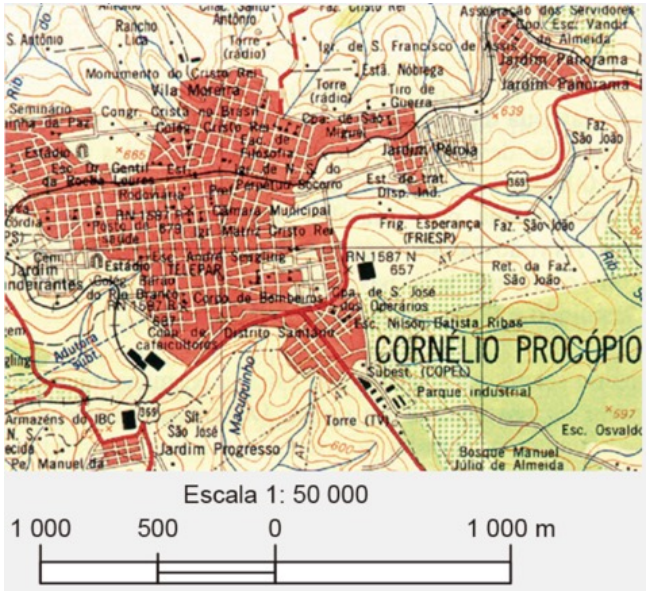
DIREITOS DE REPRODUÇÃO RESERVADOS

Impressa no Serviço Gráfico do IBGE

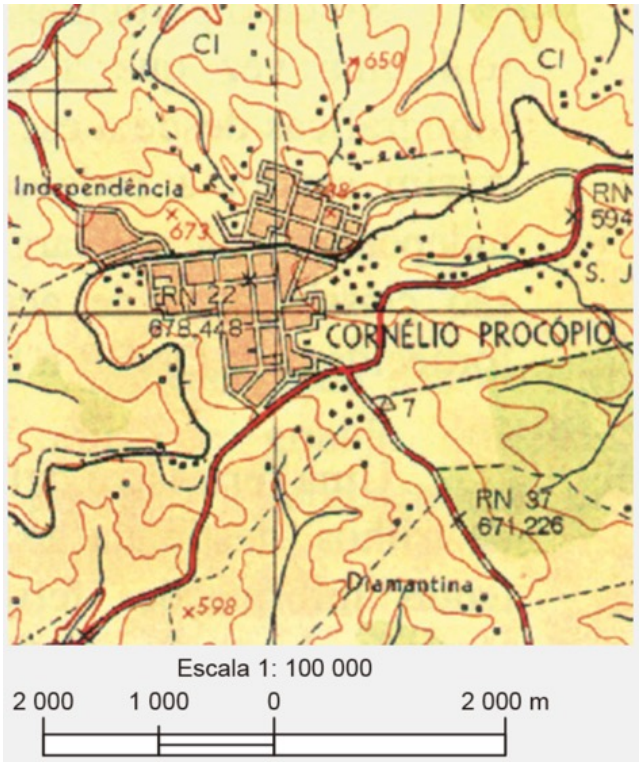
A SUPERINTENDÊNCIA DE CARTOGRAFIA agradece a gentileza da comunicação de falhas ou omissões verificadas nesta Folha

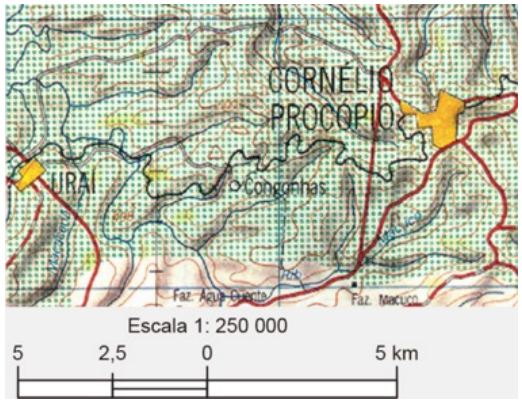


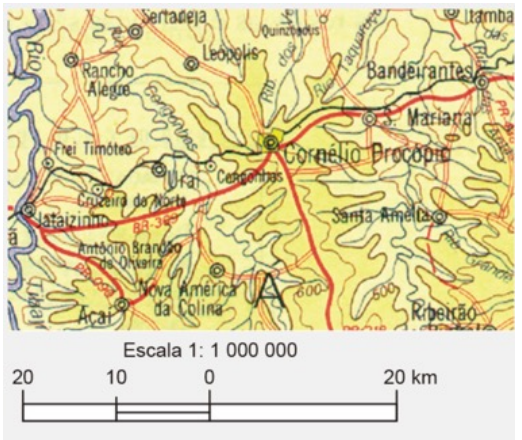
Map scale refers to the relationship (or ratio) between distance on a map and the corresponding distance on the ground. For example, on a 1:100000 scale map, 1cm on the map equals 1km on the ground.



https://atlasescolar.ibge.gov.br/conceitos-gerais/o-que-e-cartografia/escala.html







How to describe a SRS?

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    PARAMETER["false_northing",10000000],
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    AXIS["Northing",NORTH]]
```

WKT – Well Known Text for SRS
OGC – Open Geospatial Consortium

How to describe a SRS?

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    AUTHORITY["EPSG","4326"]]
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SRS ID
EPSG – European Petroleum Survey Group

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        PRIMEM["Greenwich",0,
            AUTHORITY["EPSG","8901"]],
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            AUTHORITY["EPSG","9122"]],
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    PARAMETER["latitude_of_origin",0],
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    PARAMETER["scale_factor",0.9996],
    PARAMETER["false_easting",500000],
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    AUTHORITY["EPSG","32723"],
    AXIS["Easting",EAST],
    AXIS["Northing",NORTH]]
```

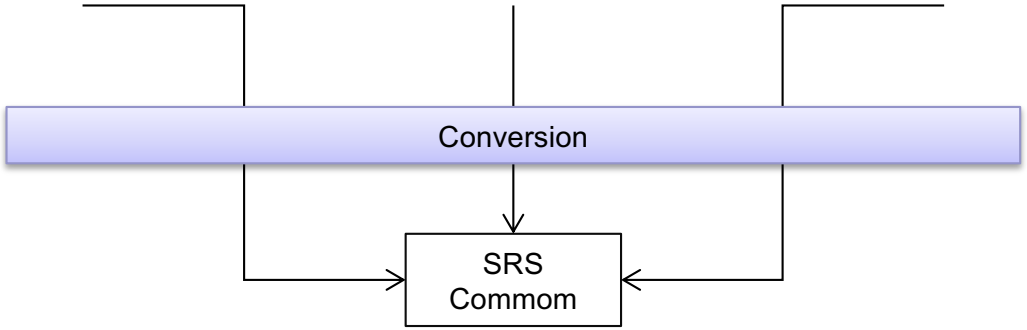
Who has determined the correct location?

	JANE		JOHN		BILL	
	X	**Y**	**X**	**Y**	**X**	**Y**
PA	-42.3591666667	-23.3194444444	770061.694961	7418652.21437	1189337.72907	-2627767.87227
PB	-43.0166666667	-29.5347222222	692193.800396	6731129.17863	1063065.76762	-3318803.38603

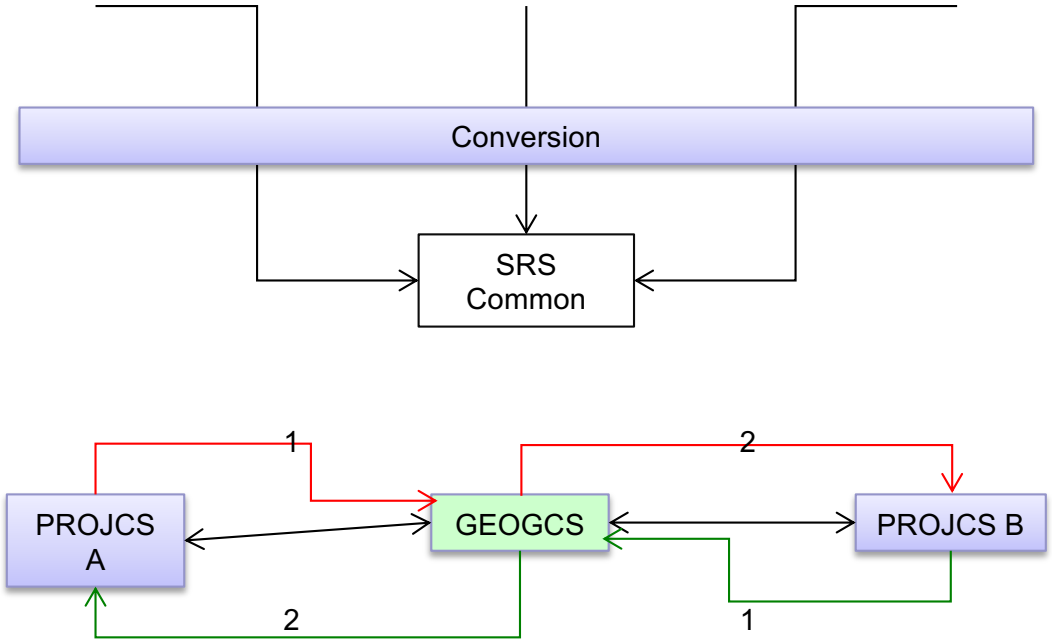
In this case, all are correct. They all refer to the same location but measured in different spatial reference systems.

Coordinate conversion

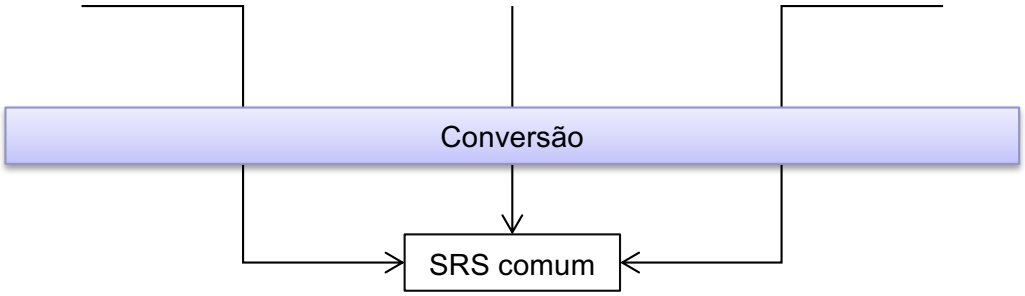
	JANE		JOHN		BILL	
	X	**Y**	**X**	**Y**	**X**	**Y**
PA	-42.3591666667	-23.3194444444	770061.694961	7418652.21437	1189337.72907	-2627767.87227
PB	-43.0166666667	-29.5347222222	692193.800396	6731129.17863	1063065.76762	-3318803.38603



Coordinates conversion



Coordinates conversion



PROJ.4

PROJ.4 - Cartographic Projections Library

OGC Well-Known Text for SRS

```
GEOGCS["WGS 84",
    DATUM["WGS_1984",
        SPHEROID["WGS 84",6378137,298.257223563]],
    PRIMEM["Greenwich",0],
    UNIT["degree",0.0174532925199433]]
```

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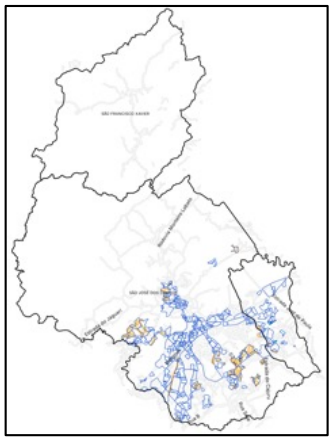
PROJCS["WGS 84 / UTM zone 23S",
    GEOGCS["WGS 84",
        DATUM["WGS_1984",
            SPHEROID["WGS 84",6378137,298.257223563],
        PRIMEM["Greenwich",0],
        UNIT["degree",0.0174532925199433]],
    UNIT["metre",1],
    PROJECTION["Transverse_Mercator"],
    PARAMETER["latitude_of_origin",0],
    PARAMETER["central_meridian",-45],
    PARAMETER["scale_factor",0.9996],
    PARAMETER["false_easting",500000],
    PARAMETER["false_northing",10000000],
    AXIS["Easting",EAST],
    AXIS["Northing",NORTH]]
```

WKT – Well Known Text for SRS
OGC – Open Geospatial Consortium

São José dos Campos, SP



São José dos Campos, SP

Which layers?

Are the data field or objects?

Are they represented as vector or raster?

What is the data source?

In with SRS they are?

What is the linking between atributes and location?