

Introduction to GIS

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NOAA / Climate Prediction Center - International Desks

Fiji Pacific Climate Early Warning Workshop

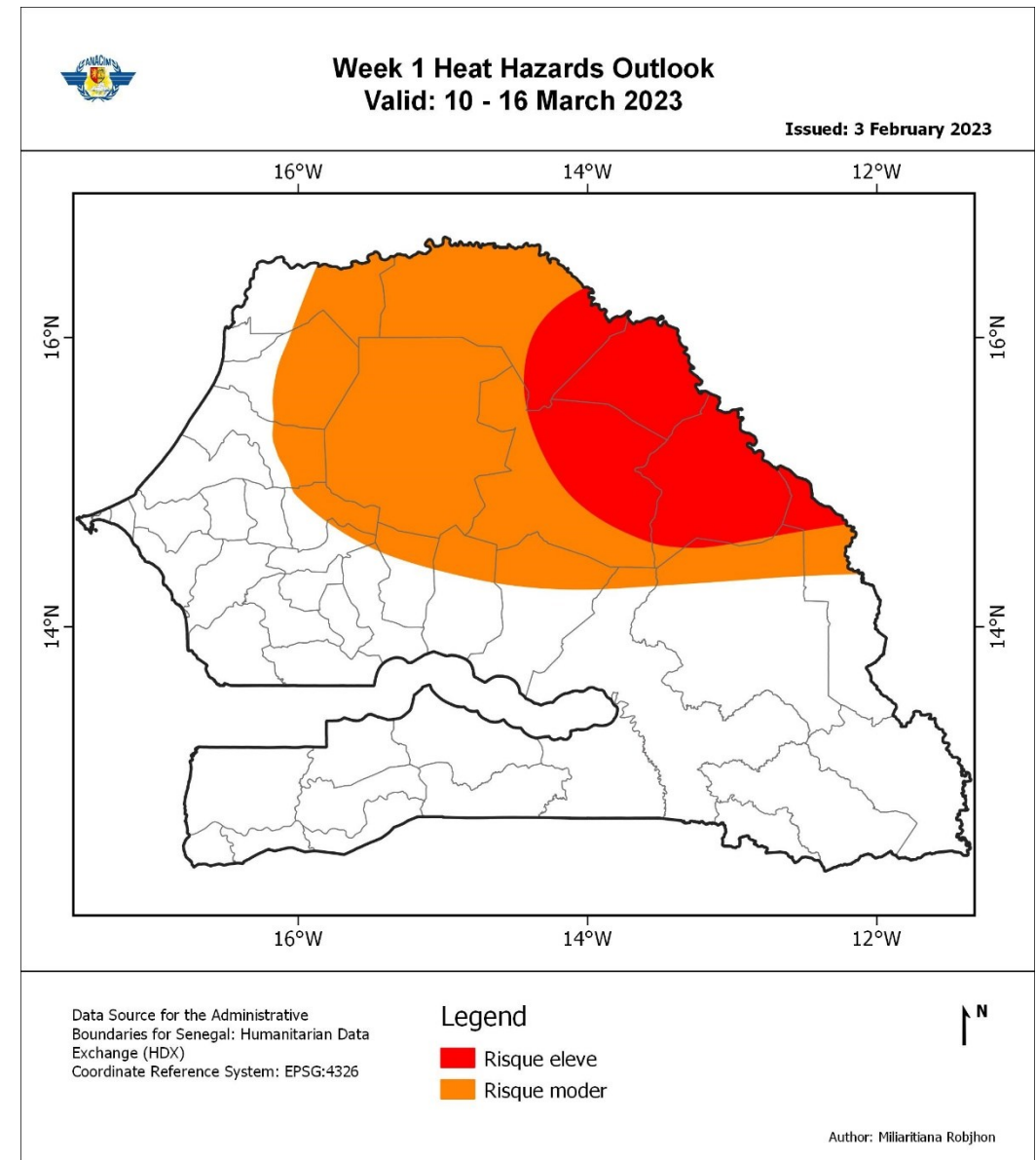
Fiji, 15 – 24 July 2023

Definition of GIS

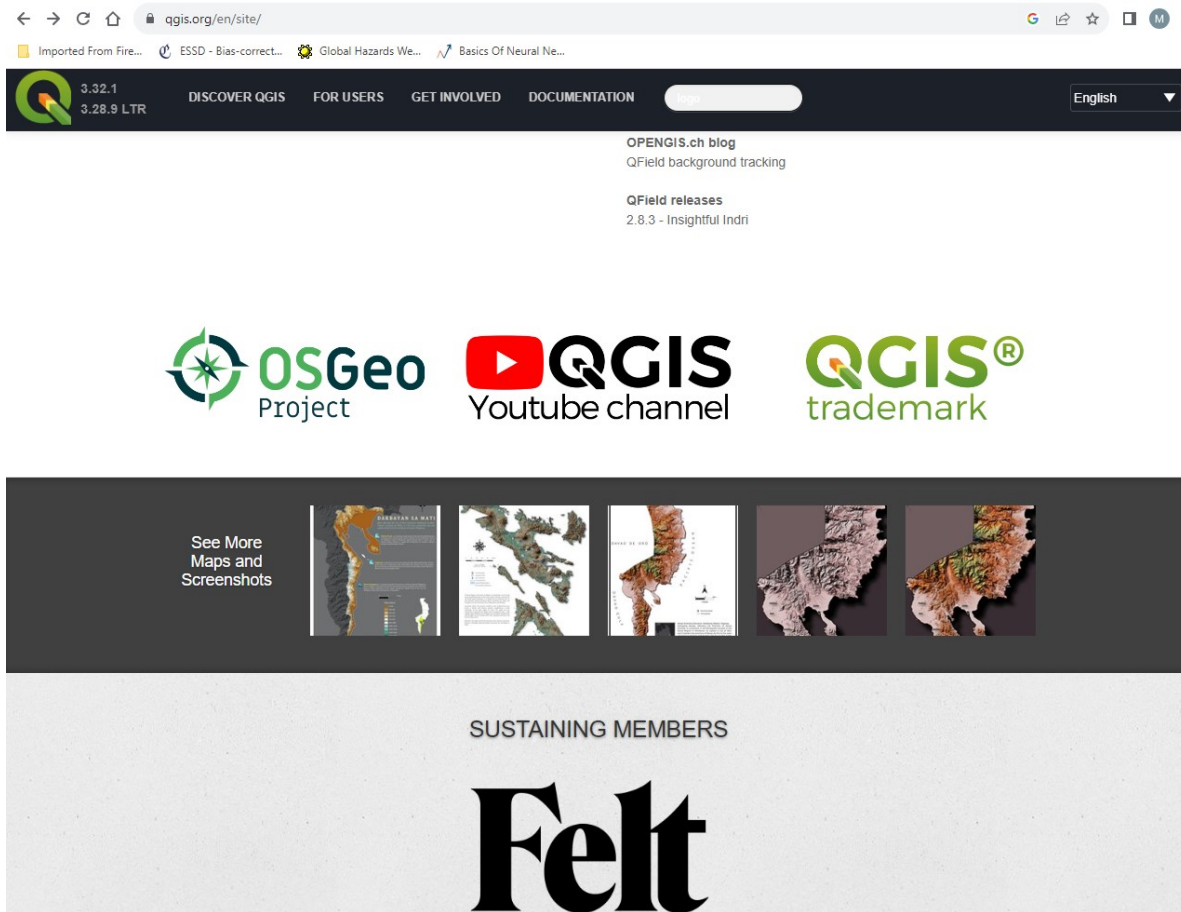
- GIS is an acronym for **Geographic Information Systems**. It is a computer-based tool that stores, analyzes, and visualizes data for geographic positions on the Earth's surface
- It needs **data** to work with, computer **hardware** to store the data, and **software** for analysis
- Choices between proprietary and open source software
 - Proprietary software requires purchase of license – example **ArcGIS**
 - Open source is free to download and use – example **QGIS**

GIS Process

- The goal is to answer real world problem – example locating flood prone areas, etc.
- Takes geographic/non geographic data and turn into new geospatial information
- Presents results in a form of maps, statistics, or reports



QGIS Background



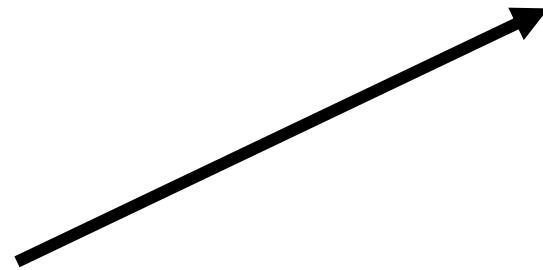
- Developed by **Gary Sherman** in early **2002**
- **Quantum GIS** version 1 officially released in **2009**
- The name was officially changed to **QGIS** in **2013**

GIS Data

- Two groups of data

• Vector

• Raster



```
All files (*)
All supported files (*.pix;*.PIX;*.nc;*.NC;*.xml;*.XML;*.jp2;*.JP2;*.jp2;*.JP2;*.j2k;*.J2K;*.pdf;*.PDF;*.mbtiles;*.MBTI
GDAL/OGR VSIFileHandler (*.zip;*.gz;*.tar;*.tar.gz;*.tgz;*.ZIP;*.GZ;*.TAR;*.TAR.GZ;*.TGZ)
(Geo)Arrow IPC File Format / Stream (*.arrow;*.feather;*.arrows;*.ipc;*.ARROW;*.FEATHER;*.ARROWS;*.IPC)
(Geo)Parquet (*.parquet;*.PARQUET)
Arc/Info ASCII Coverage (*.e00;*.E00)
AutoCAD DXF (*.dxf;*.DXF)
AutoCAD Driver (*.dwg;*.DWG)
Bathymetry Attributed Grid (*.bag;*.BAG)
Comma Separated Value (*.csv;*.CSV)
Czech Cadastral Exchange Data Format (*.vfk;*.VFK)
EDIGEO (*.thf;*.THF)
ESRI Personal GeoDatabase (*.mdb;*.MDB)
ESRI Shapefiles (*.shp;*.shz;*.shp.zip;*.SHP;*.SHZ;*.SHP.ZIP)
ESRIJSON (*.json;*.JSON)
FlatGeobuf (*.fgb;*.FGB)
GMT ASCII Vectors (.gmt) (*.gmt;*.GMT)
GPS eXchange Format [GPX] (*.gpx;*.GPX)
GPSBabel (*.mps;*.gdb;*.osm;*.tcx;*.igc;*.MPS;*.GDB;*.OSM;*.TCX;*.IGC)
GeoJSON (*.geojson;*.GEOJSON)
GeoJSON Newline Delimited JSON (*.geojsonl;*.geojsons;*.nlgeojson;*.json;*.GEOJSONL;*.GEOJSONS;*.NLGEOJ)
GeoPackage (*.gpkg;*.GPKG)
GeoRSS (*.xml;*.XML)
Geoconcept (*.gxt;*.bxt;*.GXT;*.TXT)
Geography Markup Language [GML] (*.gml;*.GML)
Geospatial PDF (*.pdf;*.PDF)
INTERLIS 1 (*.itf;*.xml;*.ili;*.ITF;*.XML;*.ILI)
INTERLIS 2 (*.xtf;*.xml;*.ili;*.XTF;*.XML;*.ILI)
Idrisi Vector (.vct) (*.vct;*.VCT)
Kadaster LV BAG Extract 2.0 (*.xml;*.XML)
```

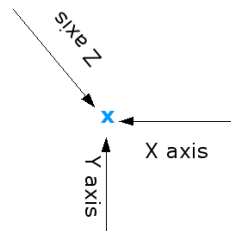
```
IRIS data (*.ppi;*.PPI)
Idrisi Raster A.1 (*.rst;*.RST)
International Service for the Geoid (*.isg;*.ISG)
JPEG JFIF (*.jpg;*.jpeg;*.JPG;*.JPEG)
Japanese DEM (*.mem;*.MEM)
KOLOR Raw (*.kro;*.KRO)
Kml Super Overlay (*.kml;*.kmz;*.KML;*.KMZ)
Leveller heightfield (*.ter;*.TER)
MBTiles (*.mbtiles;*.MBTILES)
MS Windows Device Independent Bitmap (*.bmp;*.BMP)
Magellan topo (*.bx;*.BLX)
Maptech BSB Nautical Charts (*.kap;*.KAP)
Meta Raster Format (*.mrf;*.MRF)
Multi-resolution Seamless Image Database (*.sid;*.SID)
NASA Planetary Data System 4 (*.xml;*.XML)
NOAA NGS Geoid Height Grids (*.bin;*.BIN)
NOAA Vertical Datum .GTX (*.gtx;*.GTX)
NTv2 Datum Grid Shift (*.gsb;*.gvb;*.GSB;*.GVB)
National Imagery Transmission Format (*.ntf;*.NTF)
Natural Resources Canada's Geoid (*.byn;*.err;*.BYN;*.ERR)
Network Common Data Format (*.nc;*.NC)
Northwood Classified Grid Format .grc/.tab (*.grc;*.GRC)
Northwood Numeric Grid Format .grd/.tab (*.grd;*.GRD)
PCIDSK Database File (*.pix;*.PIX)
PCRaster Raster File (*.map;*.MAP)
Portable Network Graphics (*.png;*.PNG)
Portable Pixmap Format (*.pgm;*.ppm;*.pnm;*.PGM;*.PPM;*.PNM)
R Object Data Store (*.rda;*.RDA)
R Raster (*.grd;*.GRD)
Racurs PHOTOMOD PRF (*.prf;*.PRF)
```

Vector Data

- Vector data are representation of features in real world in maps
- Characterized by **geometry** or **shapes** and **attributes**
- Will primarily focus on vector data today

Vector Point Feature

Point Geometry (indicates the x,y and z position of the feature)



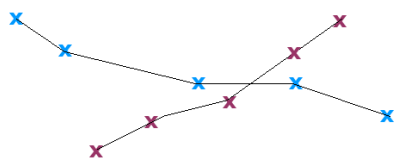
Point attributes (describe the feature)

Id, Name, Description

1, Tree, Outside our classroom
2, Light post, At the school entrance

Vector Polyline Feature

Polyline Geometry (a series of connected vertices that do not form an enclosed shape)



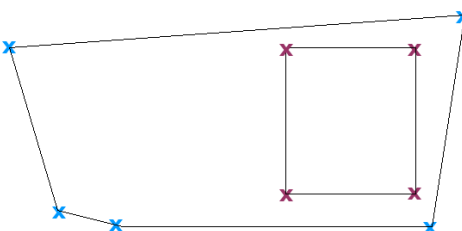
Polyline attributes (describe the feature)

Id, Name, Description

1, Footpath 1, From class to the playground
2, Footpath 2, From the school gate to the hall

Vector Polygon Feature

Polygon Geometry (a series of connected vertices that do form an enclosed shape)



Polygon attributes (describe the feature)

Id, Name, Description

1, School Boundary, Fenceline for the school
2, Sports Field, We play soccer here

ne_10m_admin_0_countries - Features Total: 254, Filtered: 254, Selected: 0

scale_rank	featurecla	labelrank	severegrnt	smv_a1	adm0_afl	level	type	admin	adm0_a1
1	0	3.000000	Libya	LEV	0.000000	2.000000	Sovereign coun...	Libya	LEV
2	1	6.000000	Saint Lucia	LCA	0.000000	2.000000	Sovereign coun...	Saint Lucia	LCA
3	0	5.000000	Lebanon	LBN	0.000000	2.000000	Sovereign coun...	Lebanon	LBN
4	0	4.000000	Liberia	LBR	0.000000	2.000000	Sovereign coun...	Liberia	LBR
5	0	6.000000	Lesotho	LSO	0.000000	2.000000	Sovereign coun...	Lesotho	LSO
6	0	5.000000	Lithuania	LTU	0.000000	2.000000	Sovereign coun...	Lithuania	LTU
7	0	6.000000	Liechtenstein	LIE	0.000000	2.000000	Sovereign coun...	Liechtenstein	LIE
8	0	3.000000	Sri Lanka	LKA	0.000000	2.000000	Sovereign coun...	Sri Lanka	LKA
9	0	4.000000	China	CHN	1.000000	2.000000	Country	Macao S.A.R.	MAC
10	1	6.000000	France	FRT	1.000000	2.000000	Dependency	Saint Martin	MMP
11	0	6.000000	Luxembourg	LUX	0.000000	2.000000	Sovereign coun...	Luxembourg	LUX
12	0	5.000000	Latvia	LVA	0.000000	2.000000	Sovereign coun...	Latvia	LVA
13	0	6.000000	Moldova	MDA	0.000000	2.000000	Sovereign coun...	Moldova	MDA
14	0	3.000000	Madagascar	MDG	0.000000	2.000000	Sovereign coun...	Madagascar	MDG
15	0	3.000000	Morocco	MAR	0.000000	2.000000	Sovereign coun...	Morocco	MAR
16	0	6.000000	Morocco	MCO	0.000000	2.000000	Sovereign coun...	Morocco	MCO

Show All Features

Geometry and Attributes

Geometry	Real World	Map
Points	Cities, towns, rain gauge stations, ...	Points
Lines	Roads, rivers, cyclone track, ITCZ, ...	Lines
Polygons	Continents, countries, floods, droughts, ...	Polygons

Attributes

Text or numerical information that describe the features, often organized in a table form, called **Attribute Table**

Coordinate Reference System (CRS)

- Defines how spatial dimensions on the projected map relate to the real world

- **Datum**

- **Projection**

Datum

- Physical reference systems
- Model of the Earth that is used in mapping
- Series of numbers that define the shape and size of the ellipsoid and orientation
- Chosen to give the best possible fit to the true shape of the Earth

Datum examples: WGS84, NAD27, NAD83

The coordinates of the Christchurch cathedral in New Zealand are

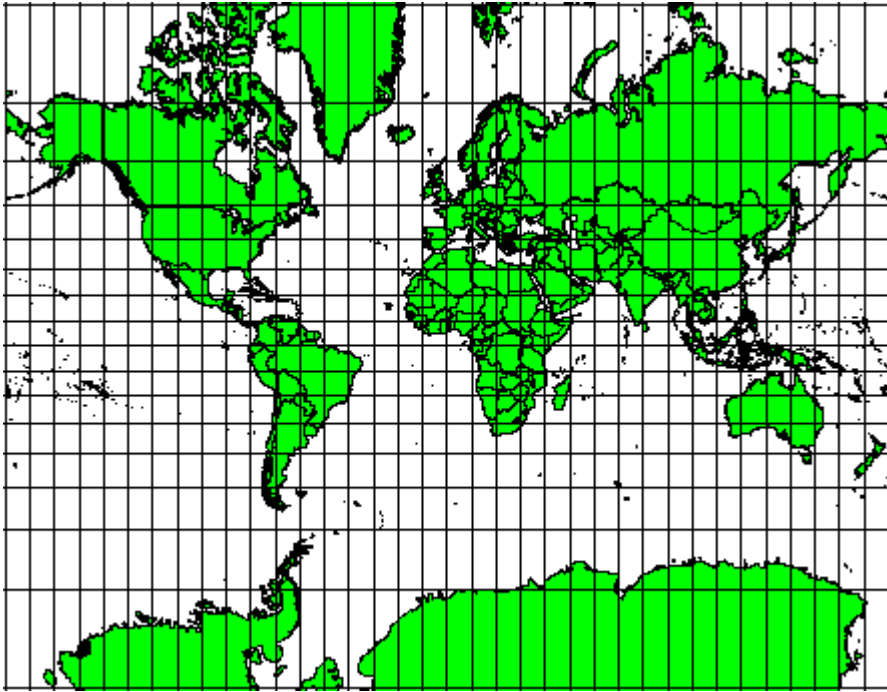
172.63658°E; 43.53103°S in WGS84 but

172.36344°E; 43.53270°S in Geodetic 1949

Projection

- A mathematical process of flattening out the Earth onto a flat plane (paper or screen)
- Convert the 3-Dimensional Earth's spherical shape to 2-Dimensional map
- Distort some elements of the map:
 - Conformality
 - Distance
 - Area
 - Direction

Conformality

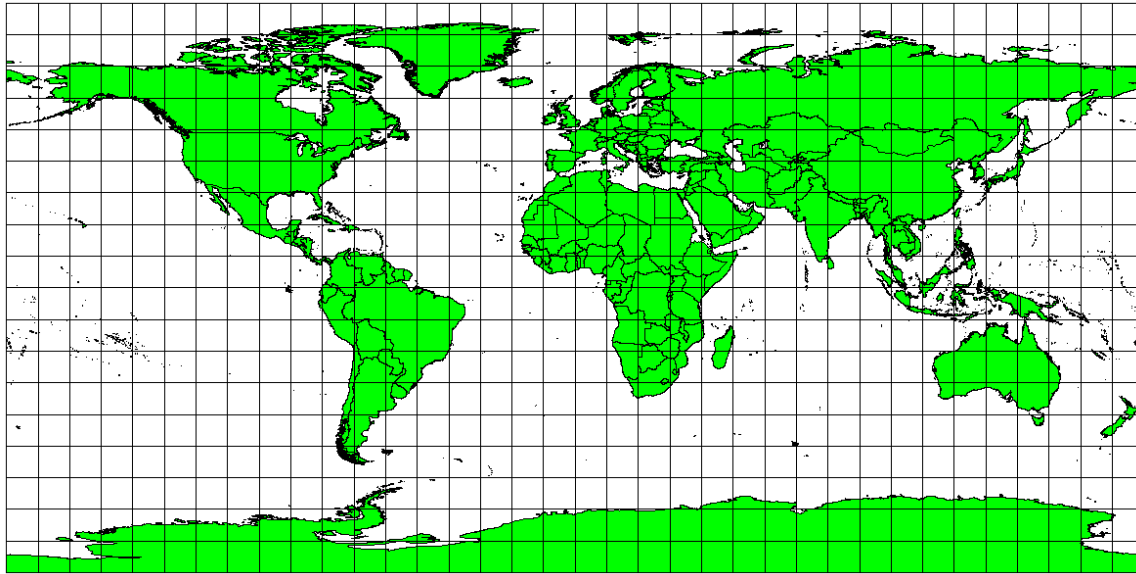


The Mercator projection

Map projection always distorts some or all elements of angular conformity, distance, and areas

The Mercator projection preserves the **angular conformity**; but distorts areas

Distance

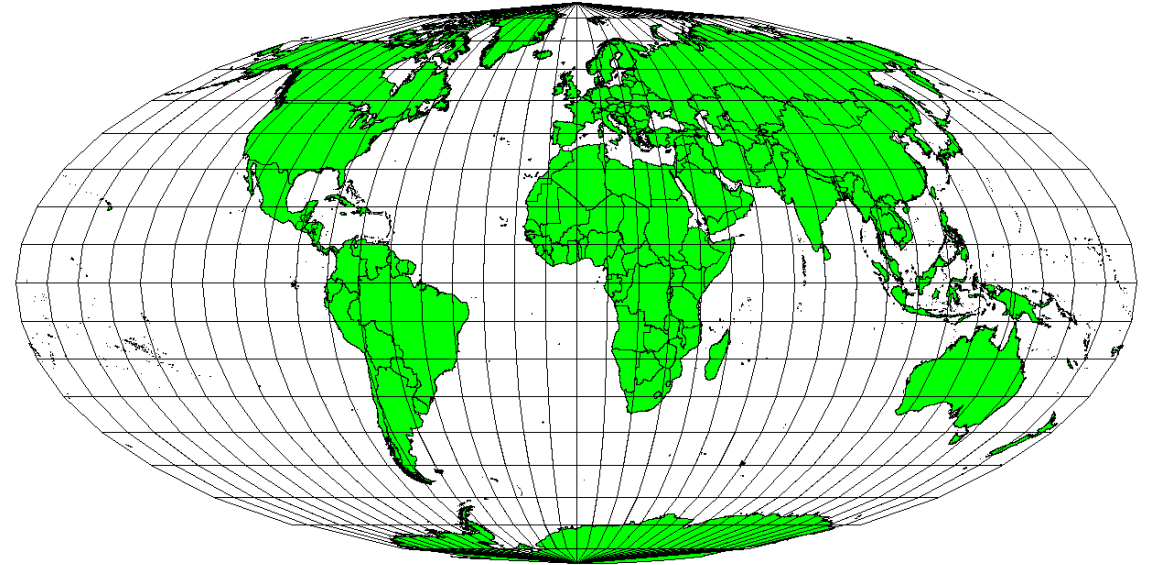


The Plate Carree Equidistant
Cylindrical projection

Equidistant projections represent distance from the center of the map to any place on the map accurately. Scale is kept constant

Area

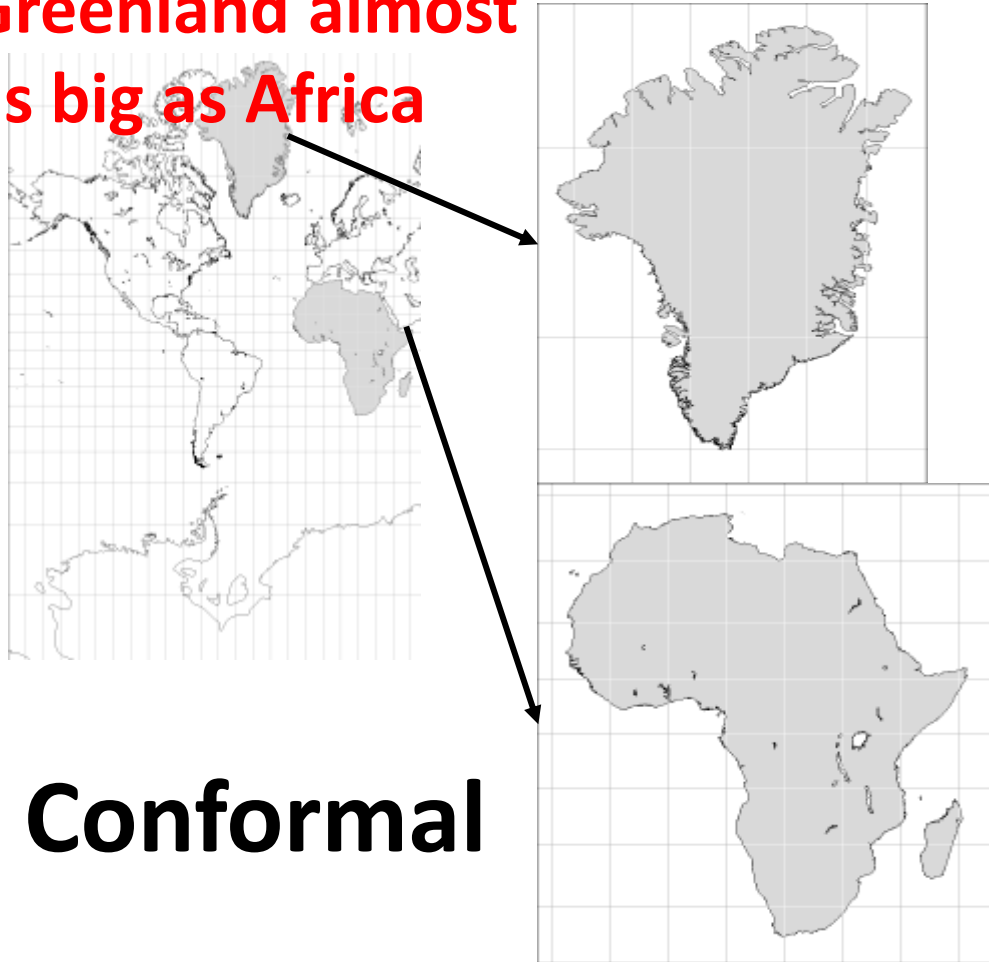
Equal area map projections preserve the area, with the same proportional relationship to the areas on the Earth; but distort angular conformity



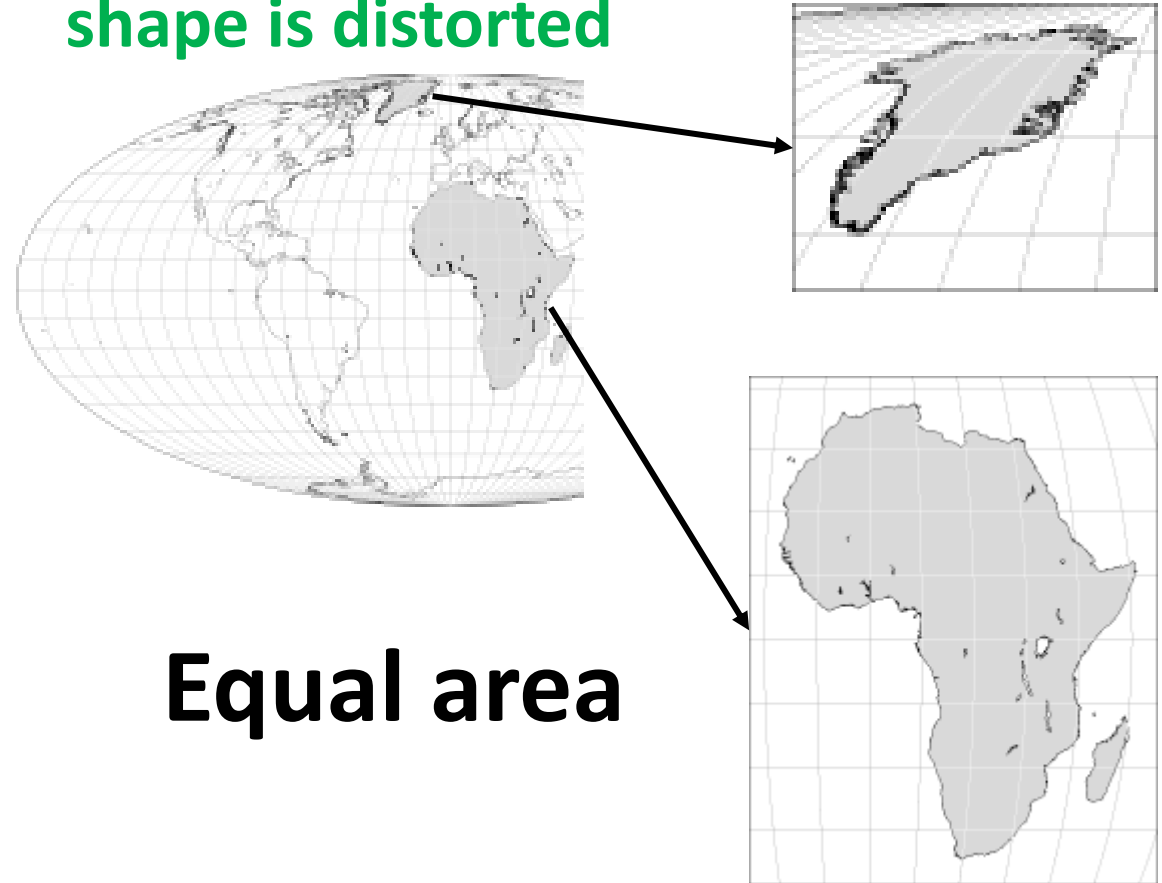
The Mollweide Equal Area Cylindrical projection

Projections (Cont'd.)

Greenland almost
as big as Africa



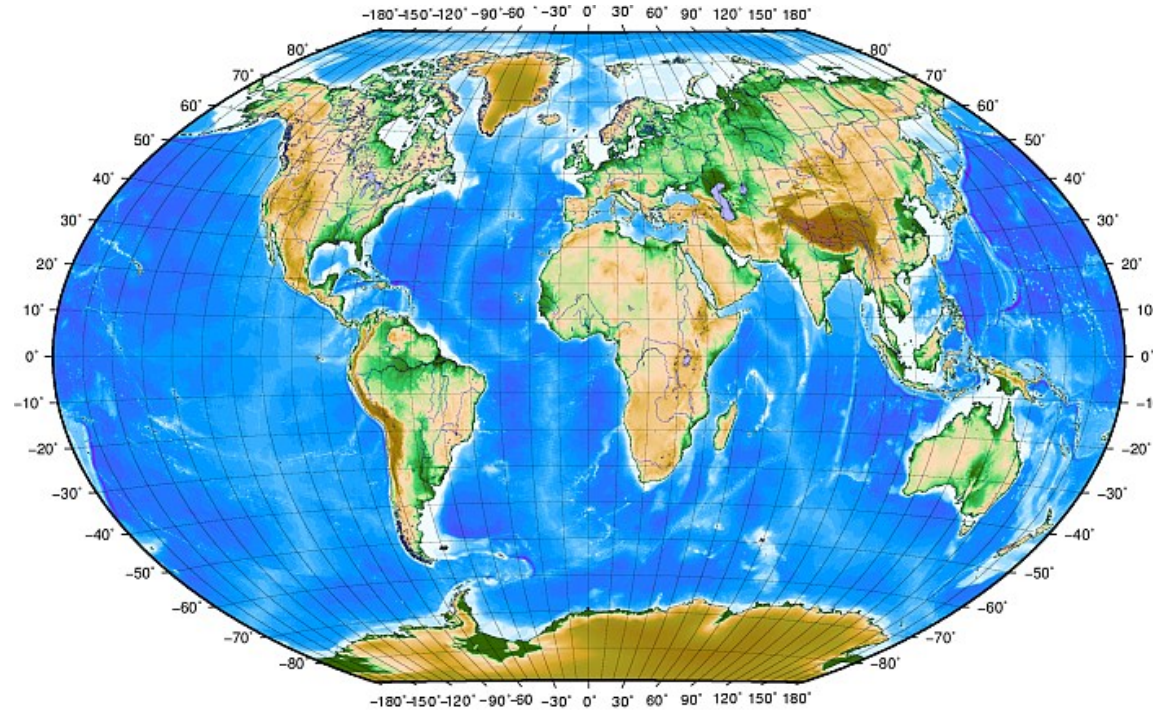
The area of Greenland
is preserved but its
shape is distorted



Geographic Coordinate Systems (GCS)

There are two main CRSs:

- **Geographic coordinate reference systems (GCS)**
- **Projected coordinate reference systems (PCS)** (also called Cartesian or rectangular)



Geographic Coordinate System with latitudes and longitudes

GCS use

degrees of latitude and longitude to locate a point on the Earth's surface

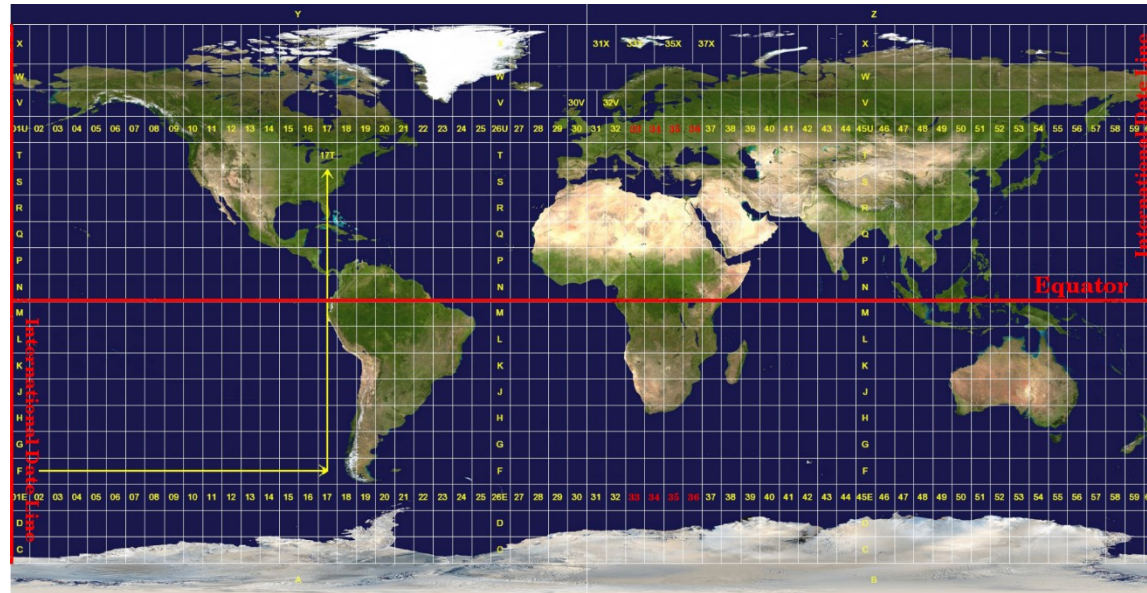
The most popular is **WGS 84**

Projected Coordinate Systems (PCS)

PCS are commonly defined by two axes at right angle to each other.

Often used PCS is the

**Universal
Transverse
Mercator
(UTM)**



The Universal Transverse Mercator zones

The UTM CRS is a global map with 60 equal zones that are six degrees wide in longitude from east to west.

Zone 1 is at 180W longitude and progresses eastward

Unit is

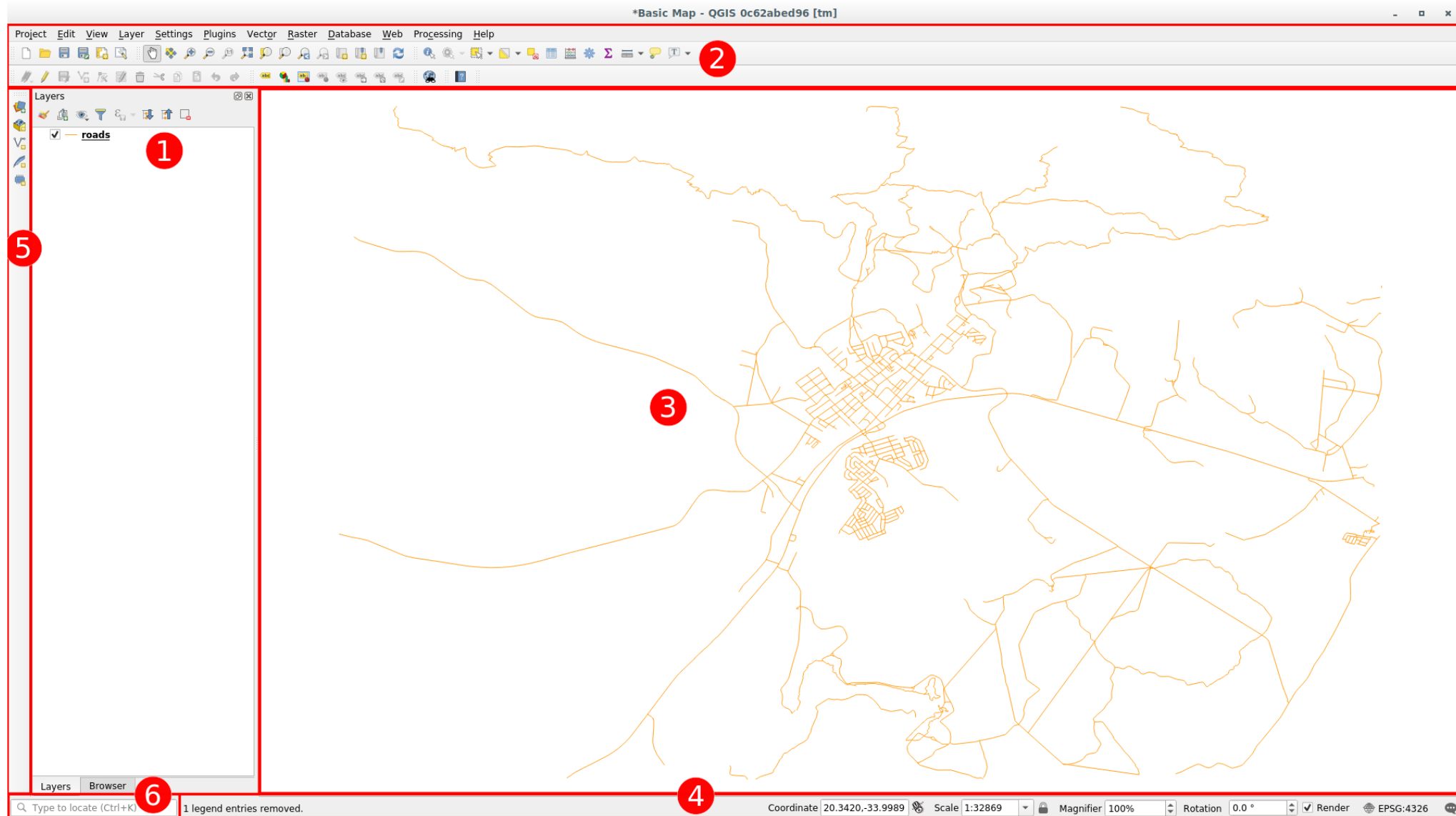
meters

Caution

- All data have to be in the same CRS before analysis or processing
- QGIS has **on-the-fly projection**, which transforms automatically data with different projections to a specific projection

QGIS

1. Layers list/Browser Panel
2. Toolbars
3. Map Canvas
4. Status Bar
5. Side Toolbar
6. Locator Bar



Practice

- Familiarization with QGIS
- Loading vector data
- Understanding CRS and reprojection
- Filtering attributes