The problem of spatial reference and scale

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Element of geodesy

Spatial references, Coordinate systems,
Projections, Datums, Ellipsoids

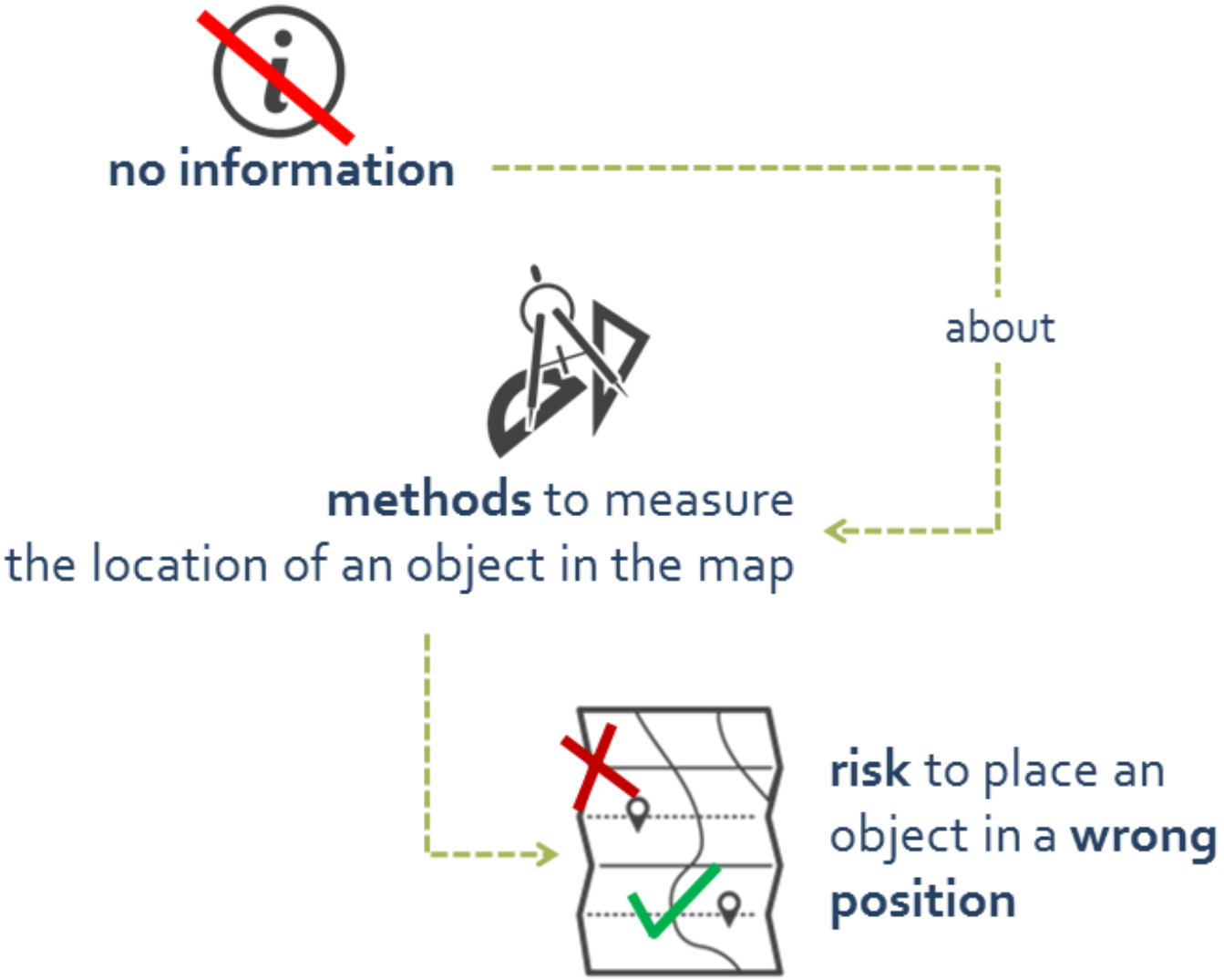
confusing?

reference

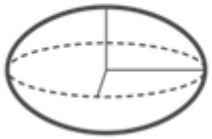
ISO – 19111
Spatial referencing
by coordinates

OGC - Topic 2
Spatial referencing
by coordinates

Element of geodesy



Element of geodesy

- **Ellipsoid**  mathematical model used to portray the earth surface
- **Systems of coordinate**  system used to point a location
- **Map projection**  transformation of spherical surface to a flat surface
- **Datum**  frame of reference for measuring locations on the surface of the earth
- **Scale**  dimensional relationship between reality and the map

Element of geodesy

how to draw a map of the earth
when the earth is more or less a sphere
and our map is a flat piece of paper
or computer screen...

Element of geodesy

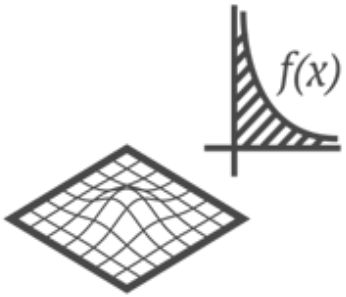
geodesy ----> science

science

deals with

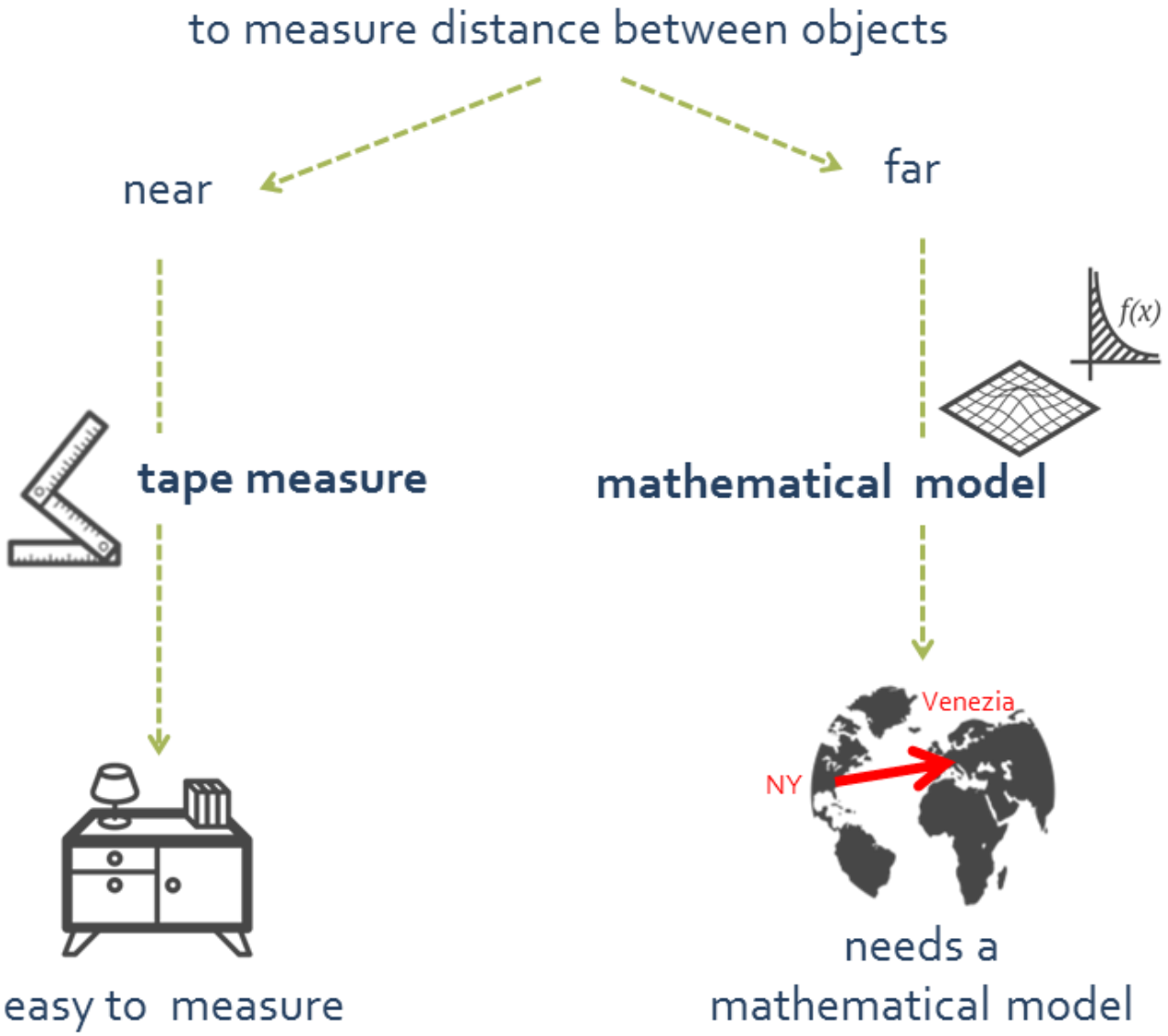
- size and shape of the earth
- earth's rotation
- earth gravitational field
- mapping earth surface

objective

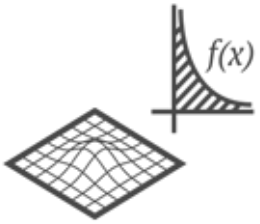


creation of physical and mathematical models of the earth

Element of geodesy



Element of geodesy

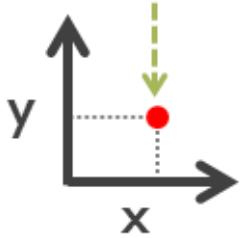


mathematical model

used to

calculate distance on earth surface

based on



the **coordinate**

a pair of numbers that point to the position of a point by reference to a **coordinate system**

set of mathematical rules for specifying how coordinates are assigned to points

Element of geodesy

problems

1. where is the center of the Earth?
2. what is the shape of the Earth?

↓

are influenced by 3 elements

Element of geodesy - ellipsoid

shape ------> 3 elements

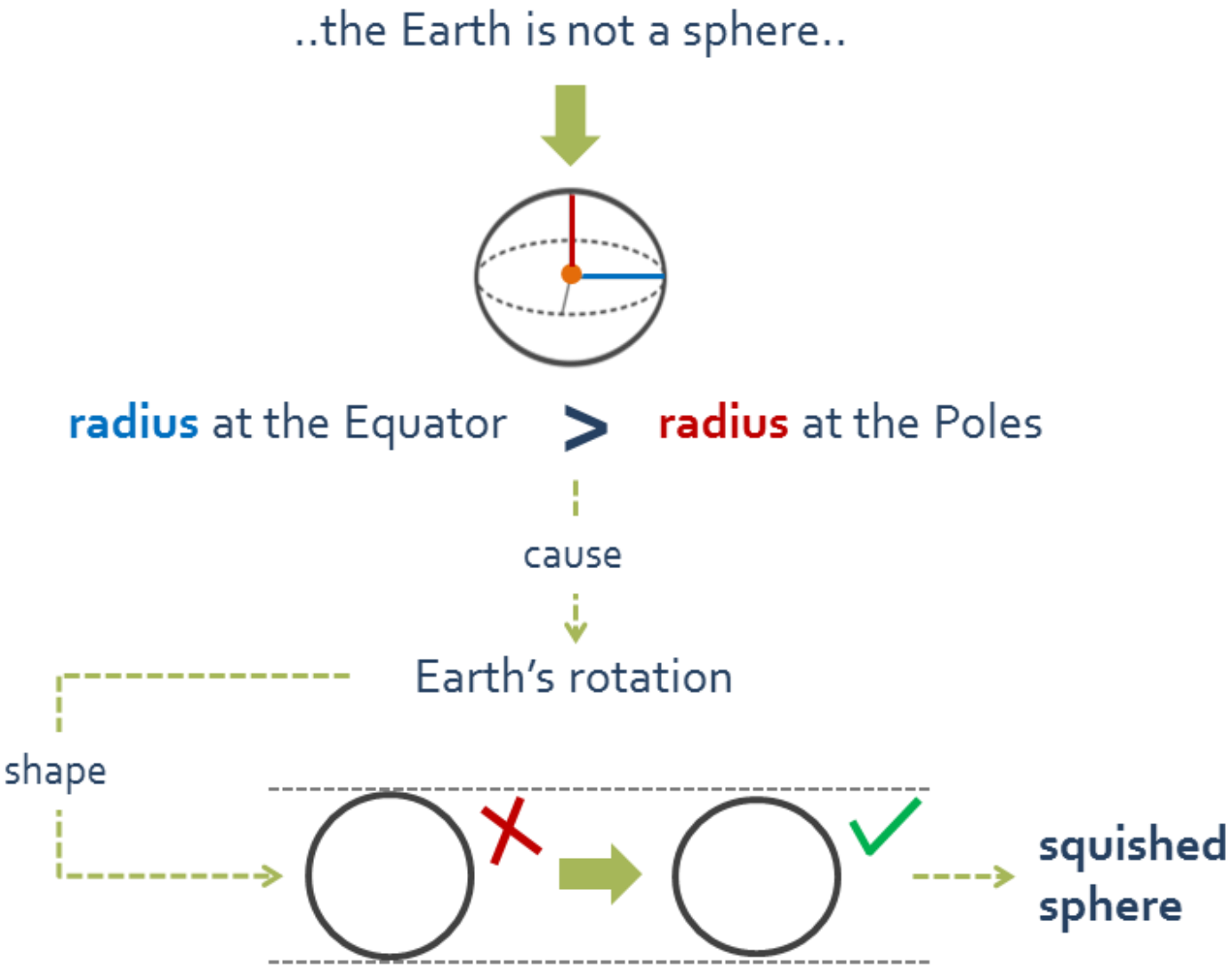
- **gravitational force**

- **earth rotation**

- **tectonic plate drift**

example --> African plate is moving toward Eurasian plate at a rate of 2 cm/year

Element of geodesy - ellipsoid

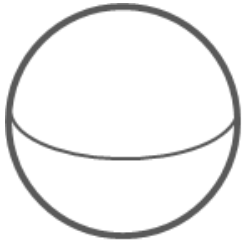


Centrifugal force: the earth rotates 460 meters per second--or roughly 1600 Km/hour

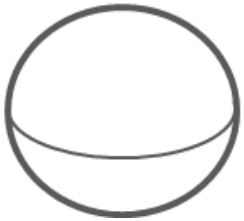
Element of geodesy - ellipsoid

bumpy surface

Earth ------> not regular geometric figure



..it is more easy to work with a **spheroid**, and accepting an error..

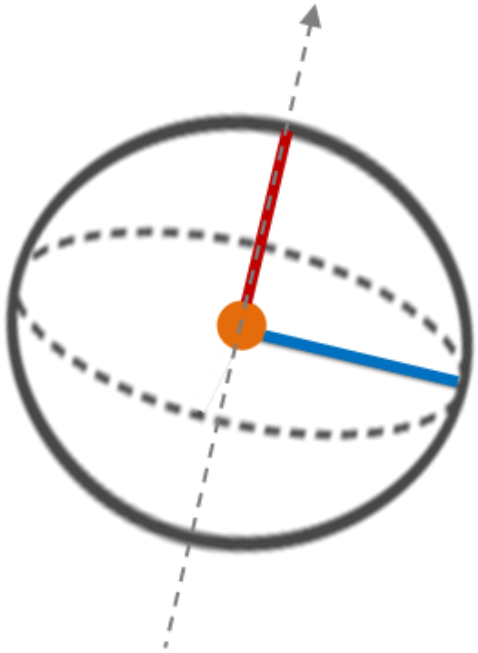


.. the spheroid is an **ellipsoid**

gain mathematical model

Element of geodesy - ellipsoid

mathematical formula
based on



parameters

ellipsoid → shape

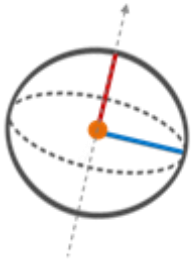
semi-minor axis → size

semi-major axis → size

orientation → orientation

center → position

Element of geodesy – datum



ellipsoid
semi-minor axis
semi-major axis
orientation
center

→ geodetic datum

Clarke team (1866)

↓

≠ measure for axis (± 100/150 m)

↑

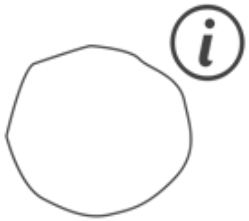
US Department of Defence (1984)

different geodetic teams

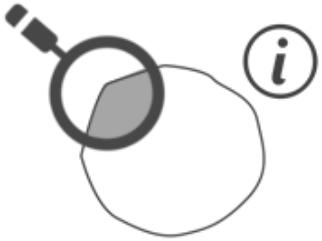
↓

different set of values
for the parameters

Element of geodesy – datum



geodetic datum ----> whole or large portion of the Earth



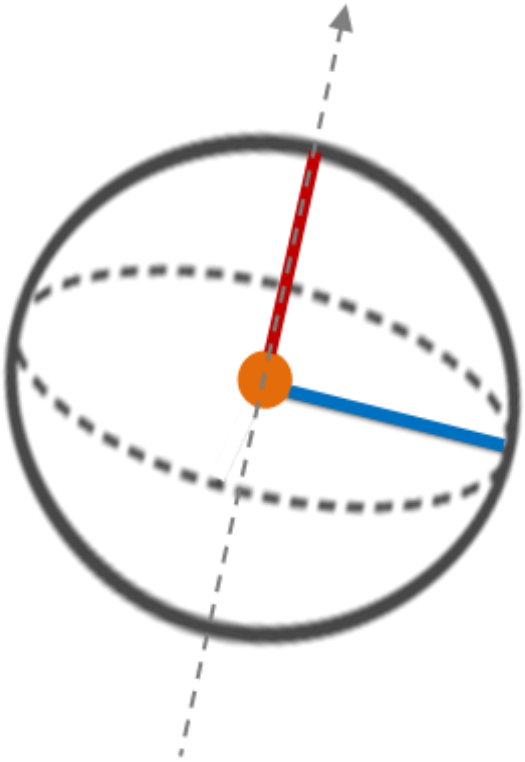
local/engineering datum ----> single countries / departments

⇩

redux error between geoid and sphere

Take home message # 1

Geodesists have adopted an **ellipsoid** model to represent the earth.



parameters

ellipsoid → shape

semi-minor axis → size

semi-major axis → size

orientation → orientation

center → position

→ **datum**

Take home message # 2

Different ellipsoid exist

Selected Reference Ellipsoids

Ellipse	Semi-Major Axis (meters)	1/Flattening
Airy 1830	6377563.396	299.3249646
Bessel 1841	6377397.155	299.1528128
Clarke 1866	6378206.4	294.9786982
Clarke 1880	6378249.145	293.465
Everest 1830	6377276.345	300.8017
Fischer 1960 (Mercury)	6378166.0	298.3
Fischer 1968	6378150.0	298.3
G R S 1967	6378160.0	298.247167427
G R S 1975	6378140.0	298.257
G R S 1980	6378137.0	298.257222101
Hough 1956	6378270.0	297.0
International	6378388.0	297.0
Krassovsky 1940	6378245.0	298.3
South American 1969	6378160.0	298.25
WGS 60	6378165.0	298.3
WGS 66	6378145.0	298.25
WGS 72	6378135.0	298.26
WGS 84	6378137.0	298.257223563

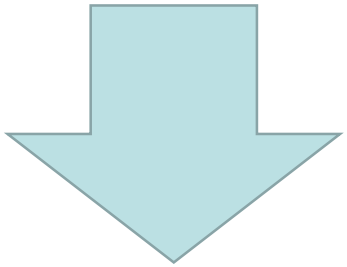
Peter H. Dana 9/1/94

Element of geodesy

Questions?

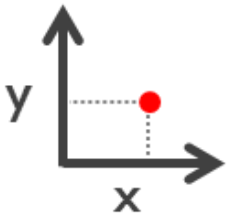
Datum and coordinate system

A **datum** defines the **position** of the spheroid **relative to the center of the earth**.



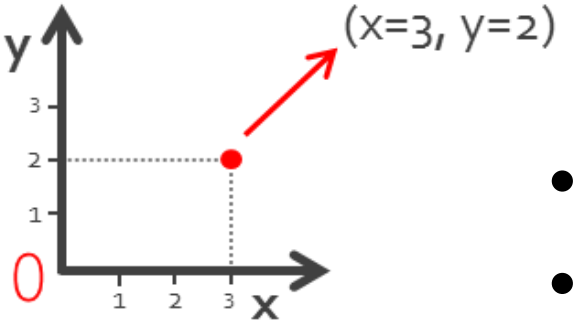
it provides a **frame of reference** for measuring locations on the surface of the earth

Datum and coordinate system



coordinate system

example



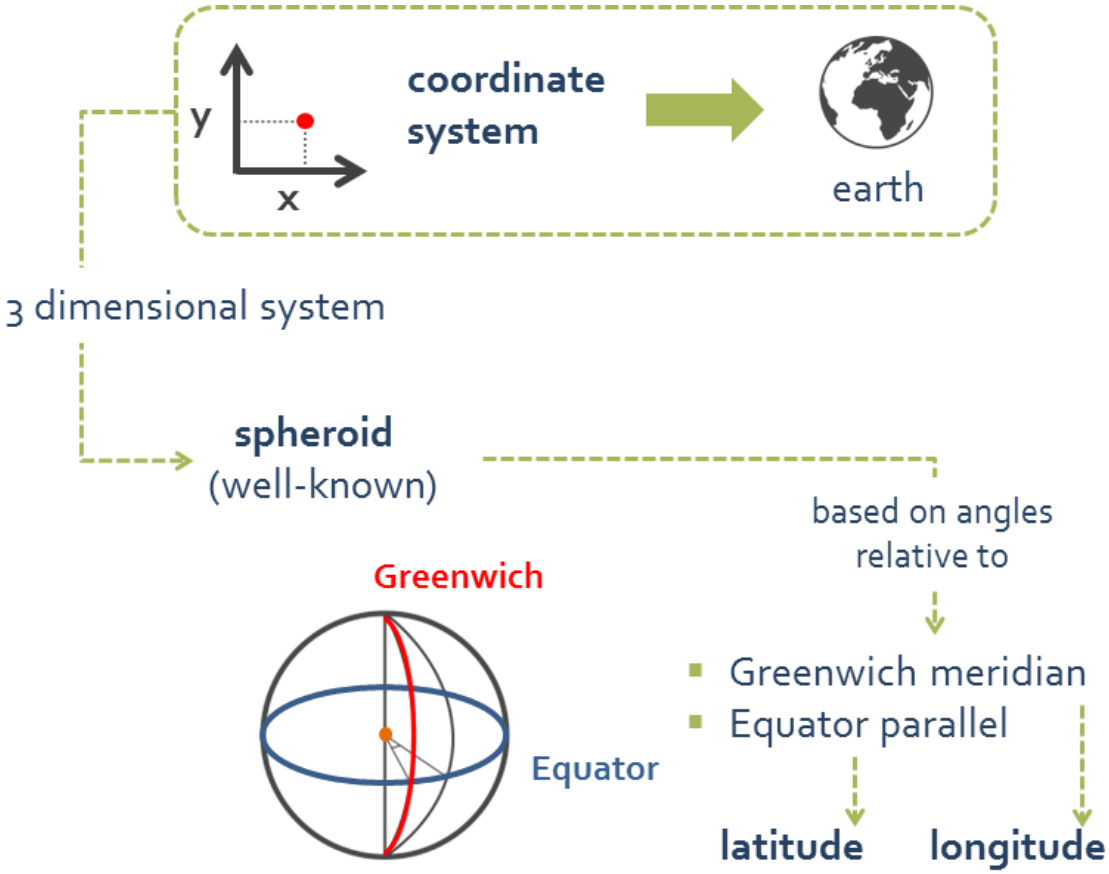
Cartesian plane

Coordinate system: system which uses coordinates to uniquely determine the position of the points on a manifold (Cartesian plane).

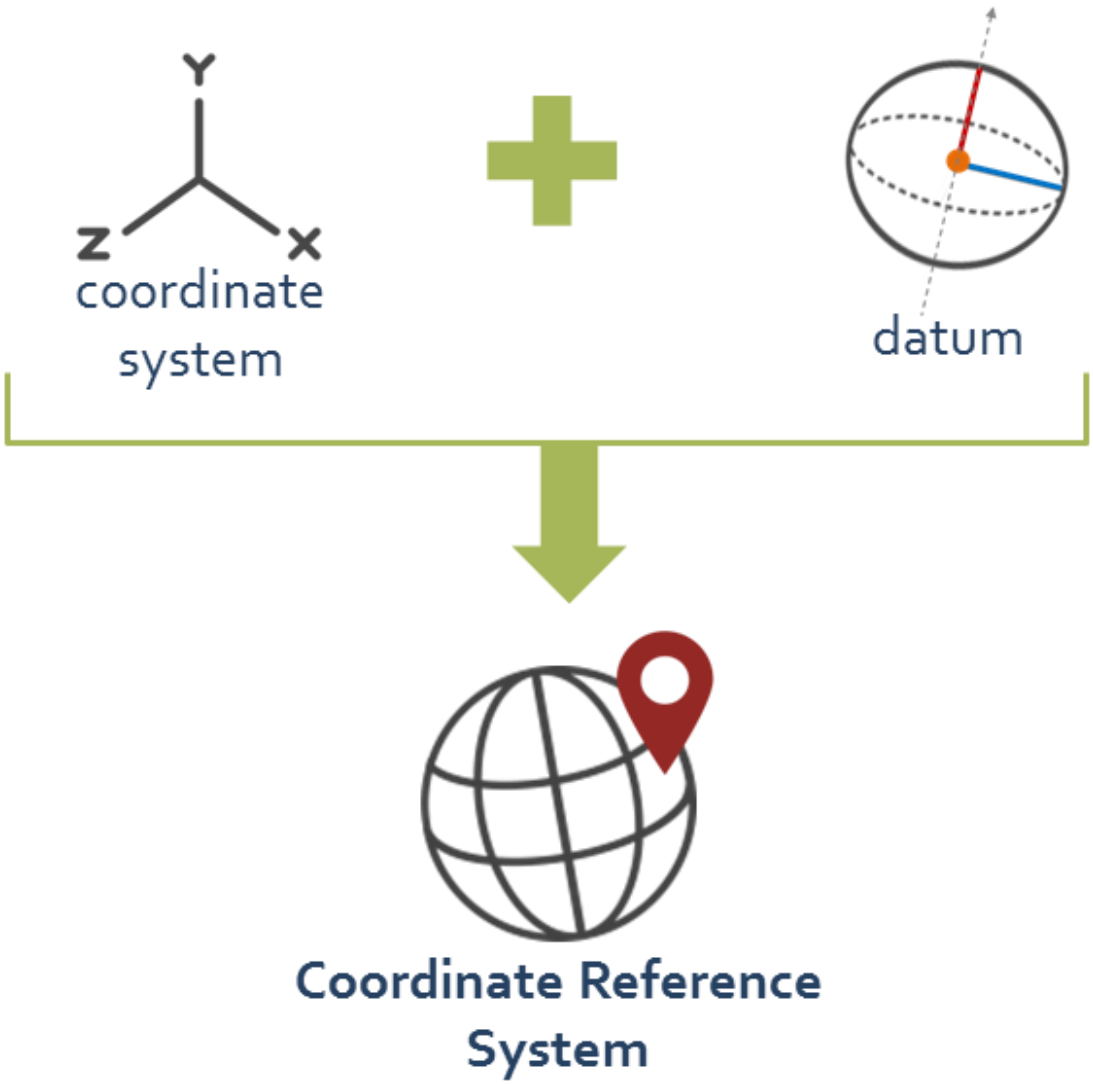
- System (Cartesian , cylindrical, spherical,..)
- Origin
- Measurement

Datum and coordinate system

A **geographic coordinate system** is a coordinate system used in geography that enables every location on Earth to be specified by a set of coordinate



Datum and coordinate system



Coordinate reference system

A coordinate system that has a reference to the Earth. Consists of a coordinate system and a datum

is required for any measurement of geographic coordinates

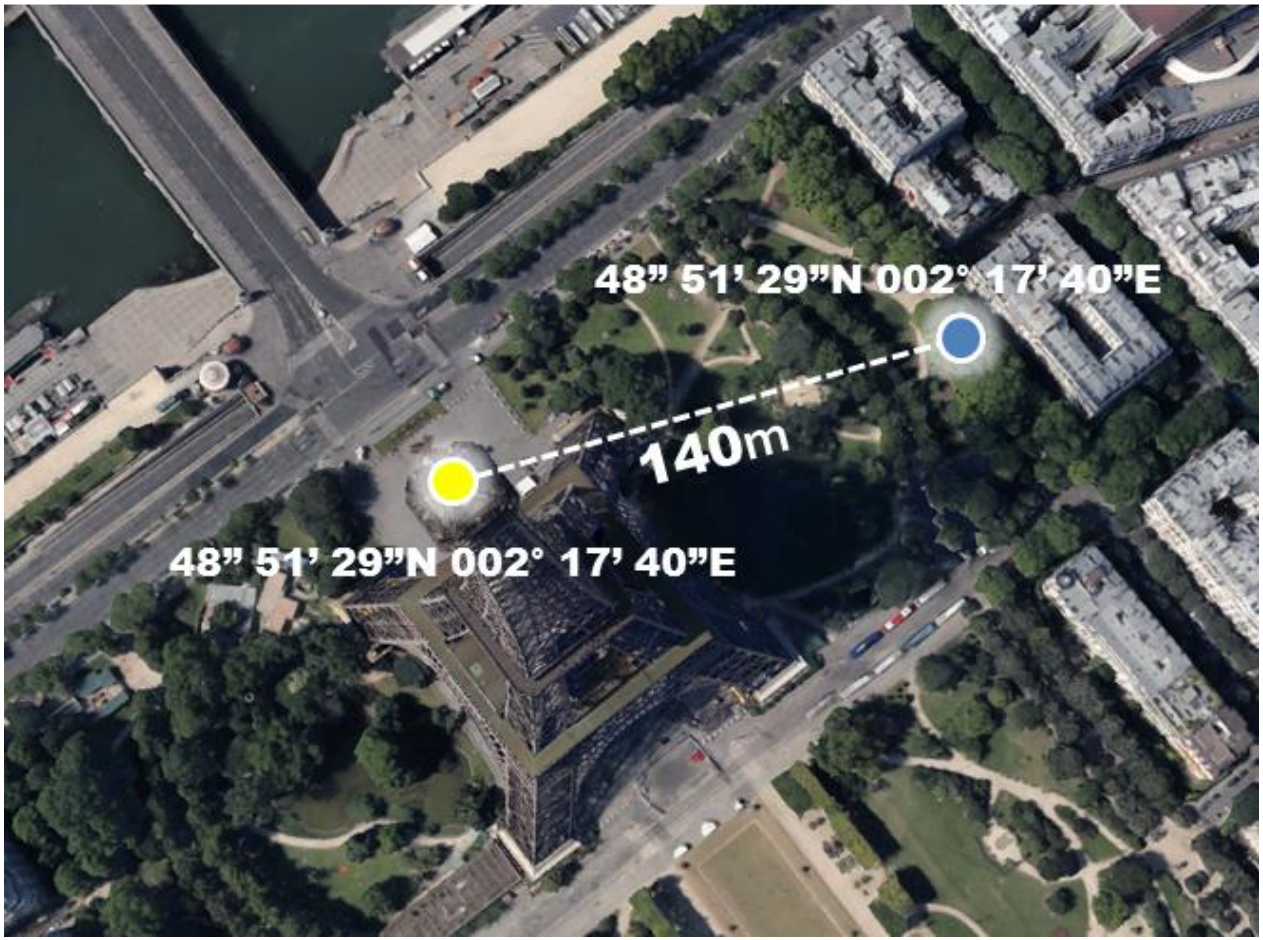
..without a CRS the coordinates values are ambiguous or meaningless..

Coordinate reference system

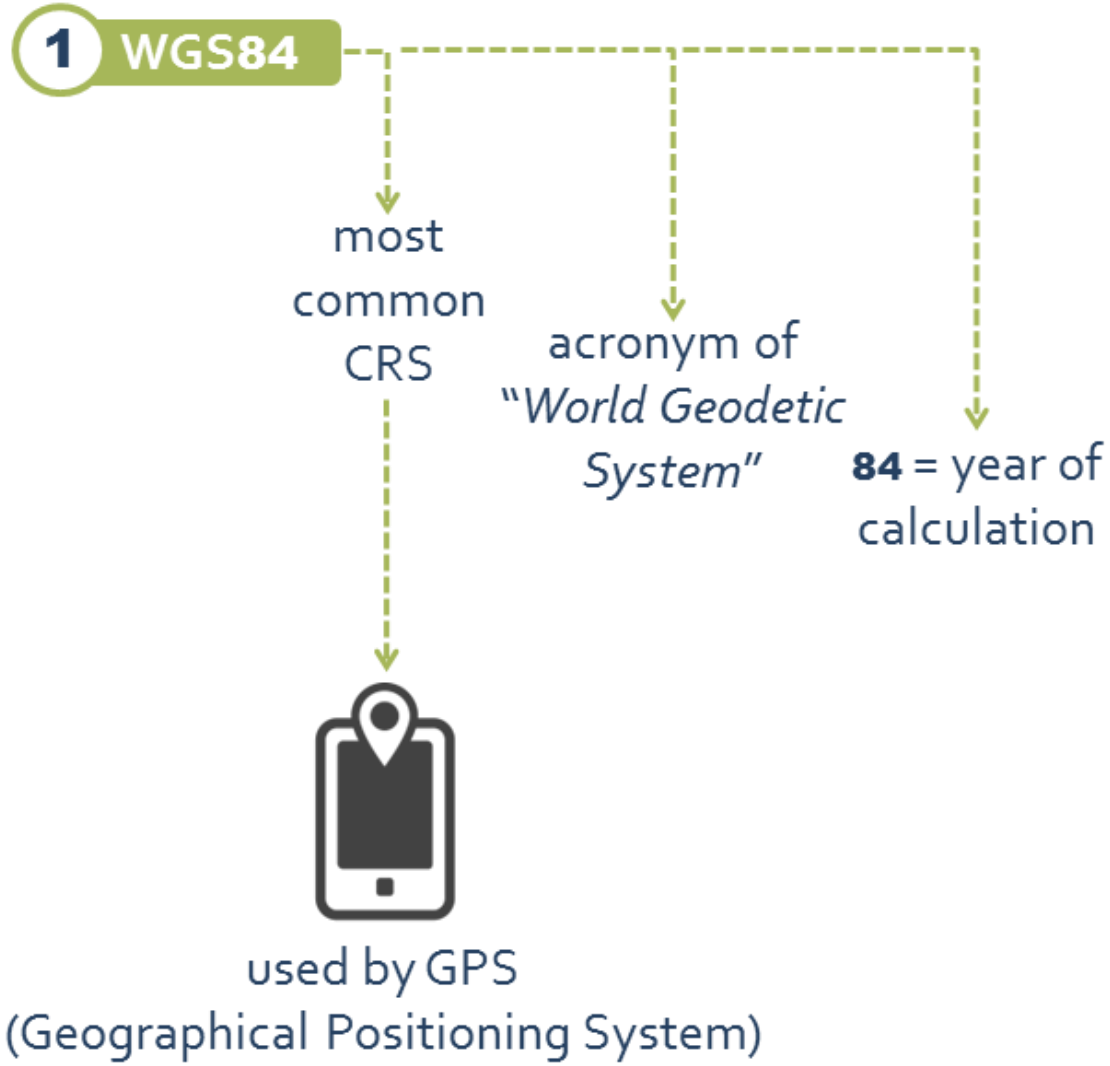
Different Coordinate reference system exist.

1 WGS84

2 ED50



Coordinate reference system



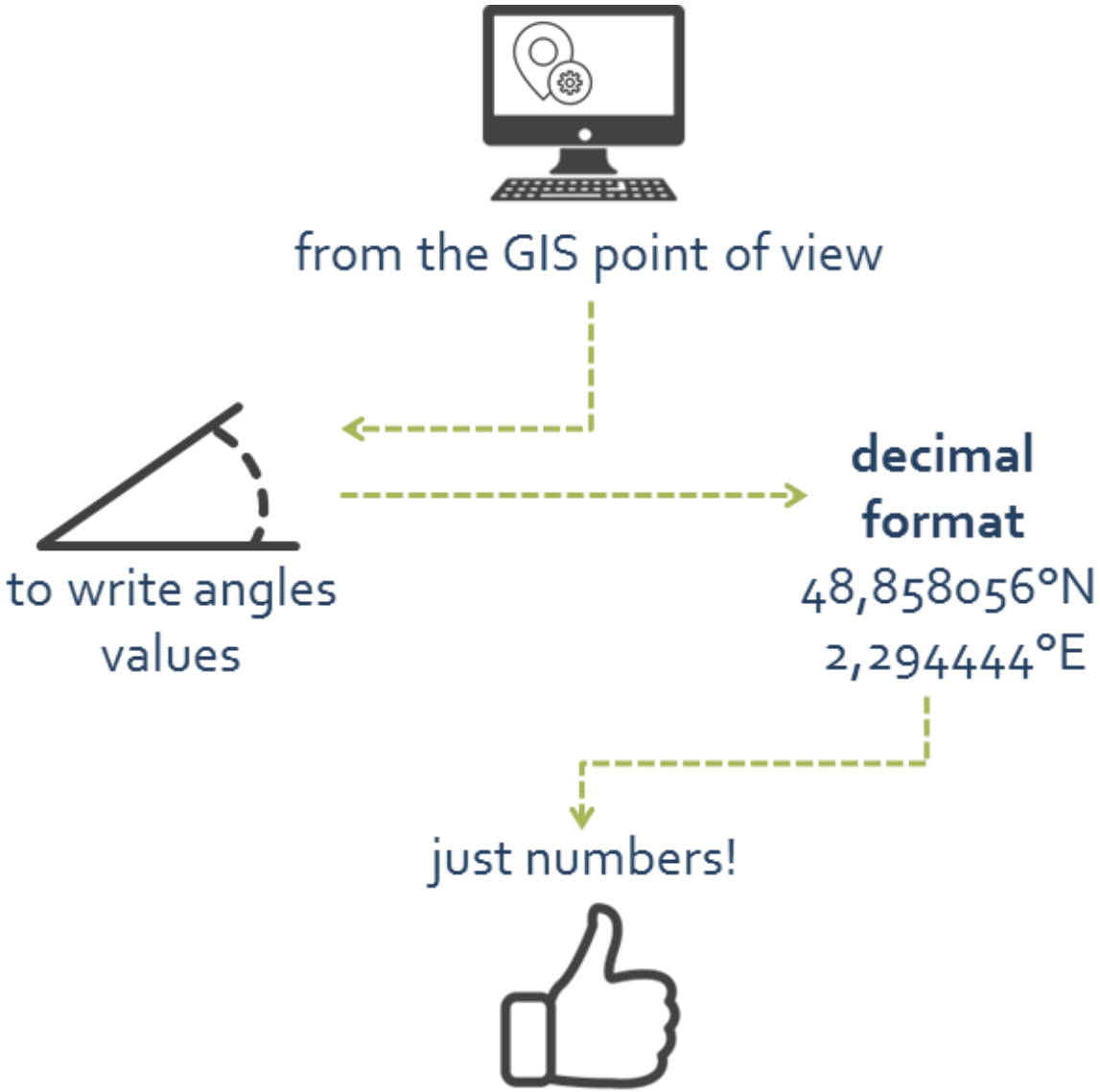
Coordinate reference system

angles to represent the coordinate values

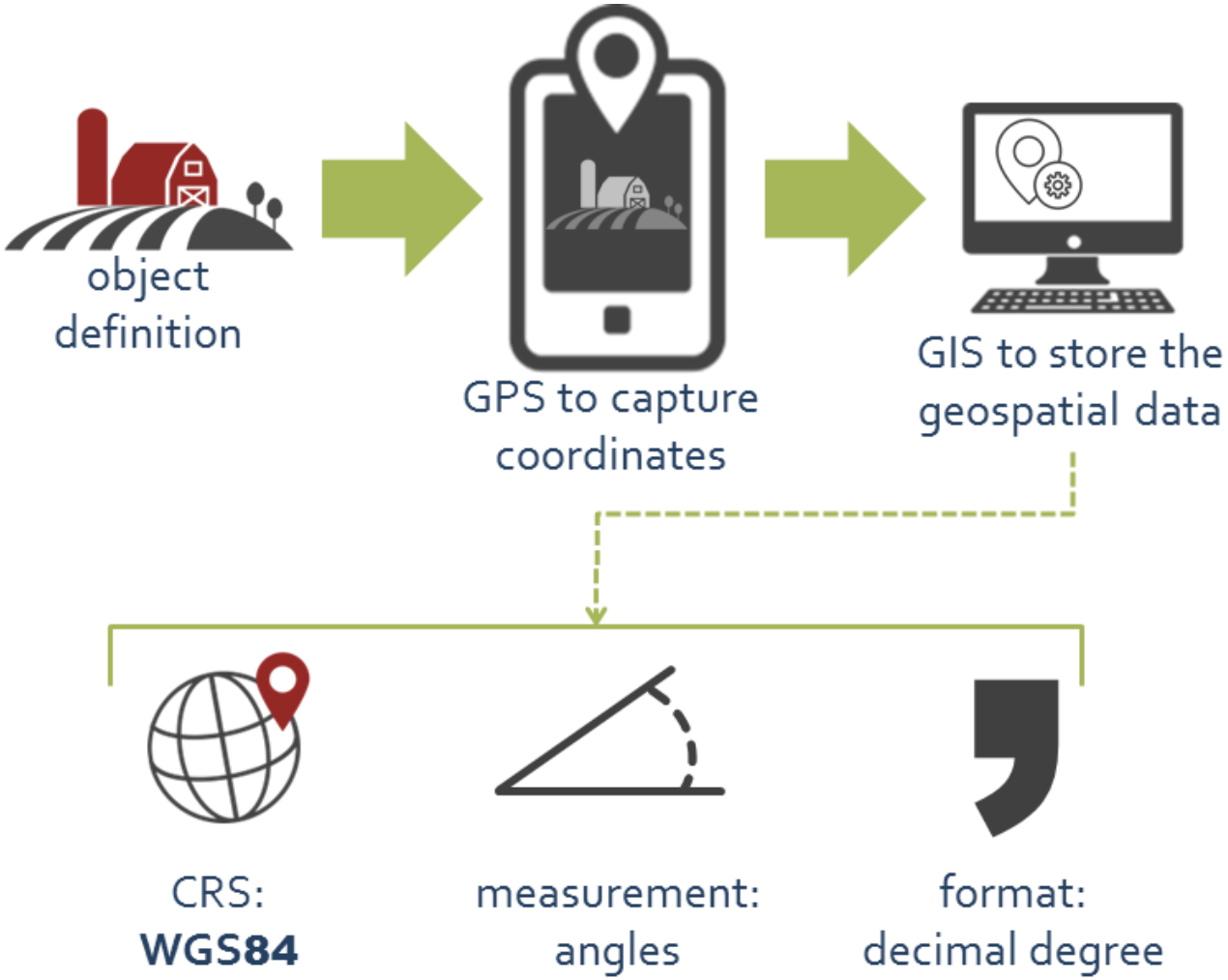
angle format

degree and decimal minutes format	sexagesimal format	decimal format
	▪ degrees ▪ minutes ▪ seconds	
48° 51,4833′N 2° 17,6666′E	48° 51′ 29″N 2° 17′ 40″E	48,858056°N 2,294444°E

Coordinate reference system



Coordinate reference system



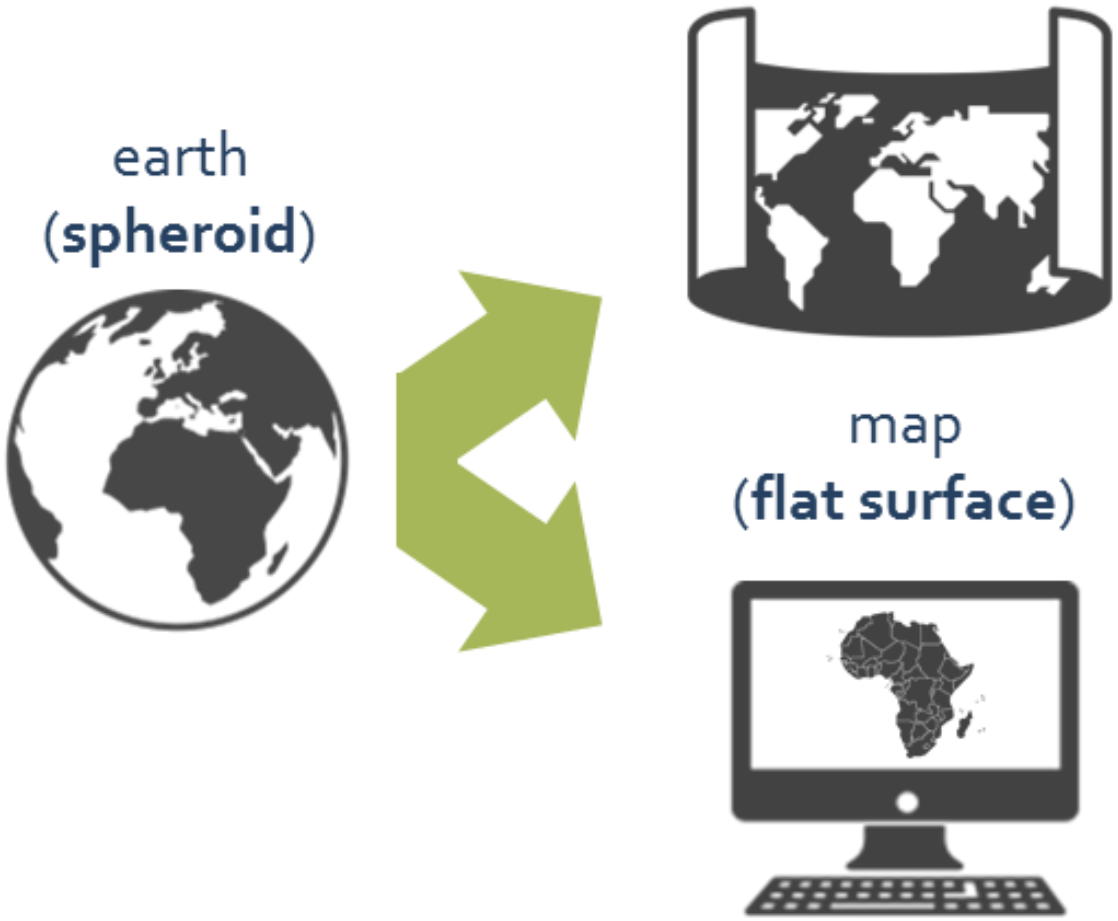
Take home message # 3

- CRS provides a framework for real-world location definition
- Coordinate values must always be expressed in terms of a CRS
- WGS84 is the commonest CRS
  - coordinates are expressed in angles
  - decimal degree suggested for representation

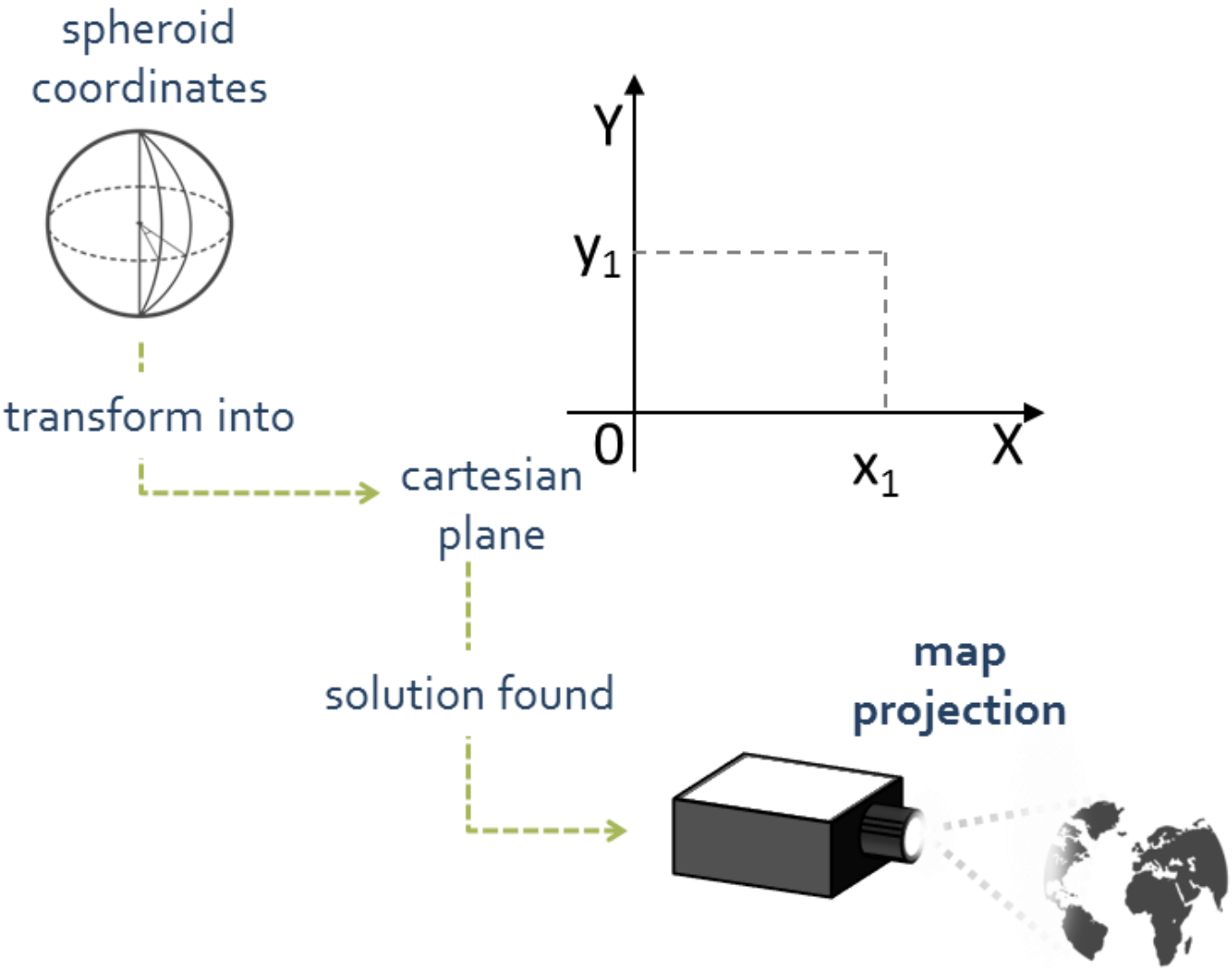
Coordinate reference system

Questions?

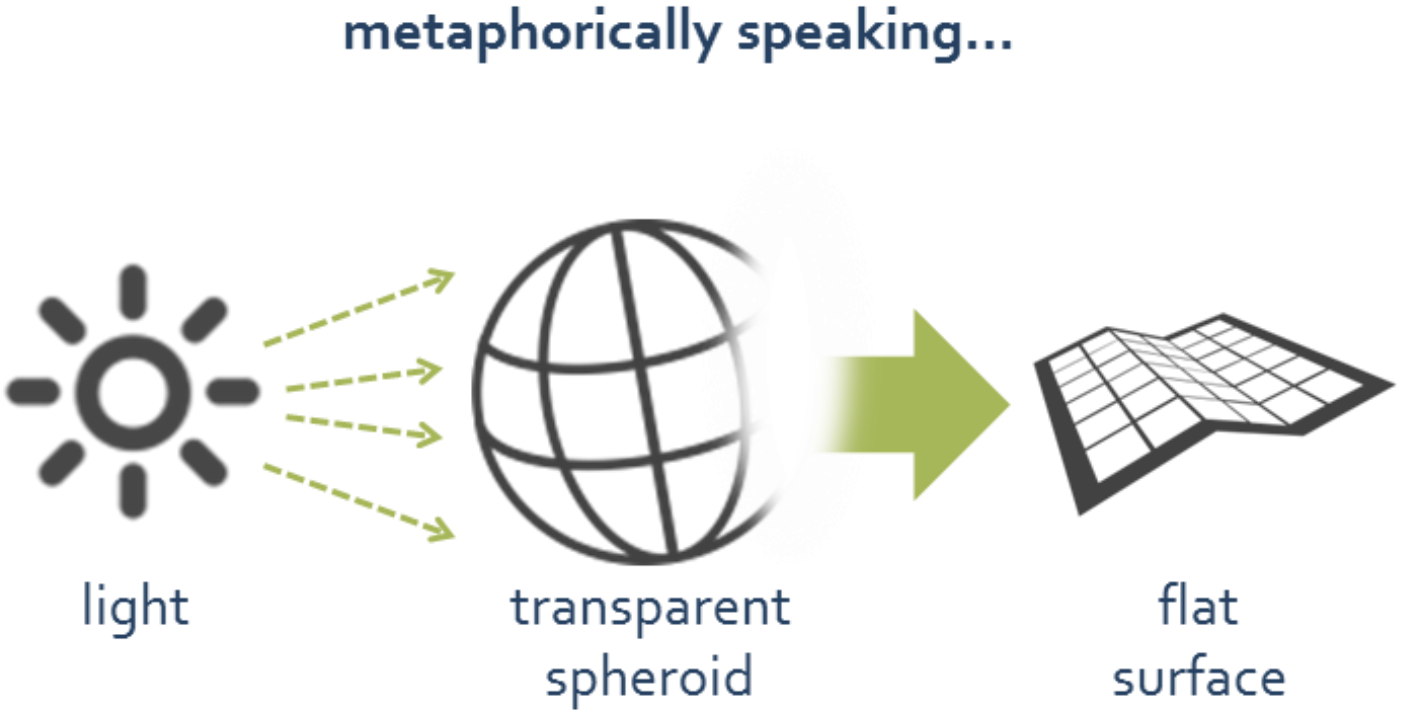
Coordinate reference system - projection



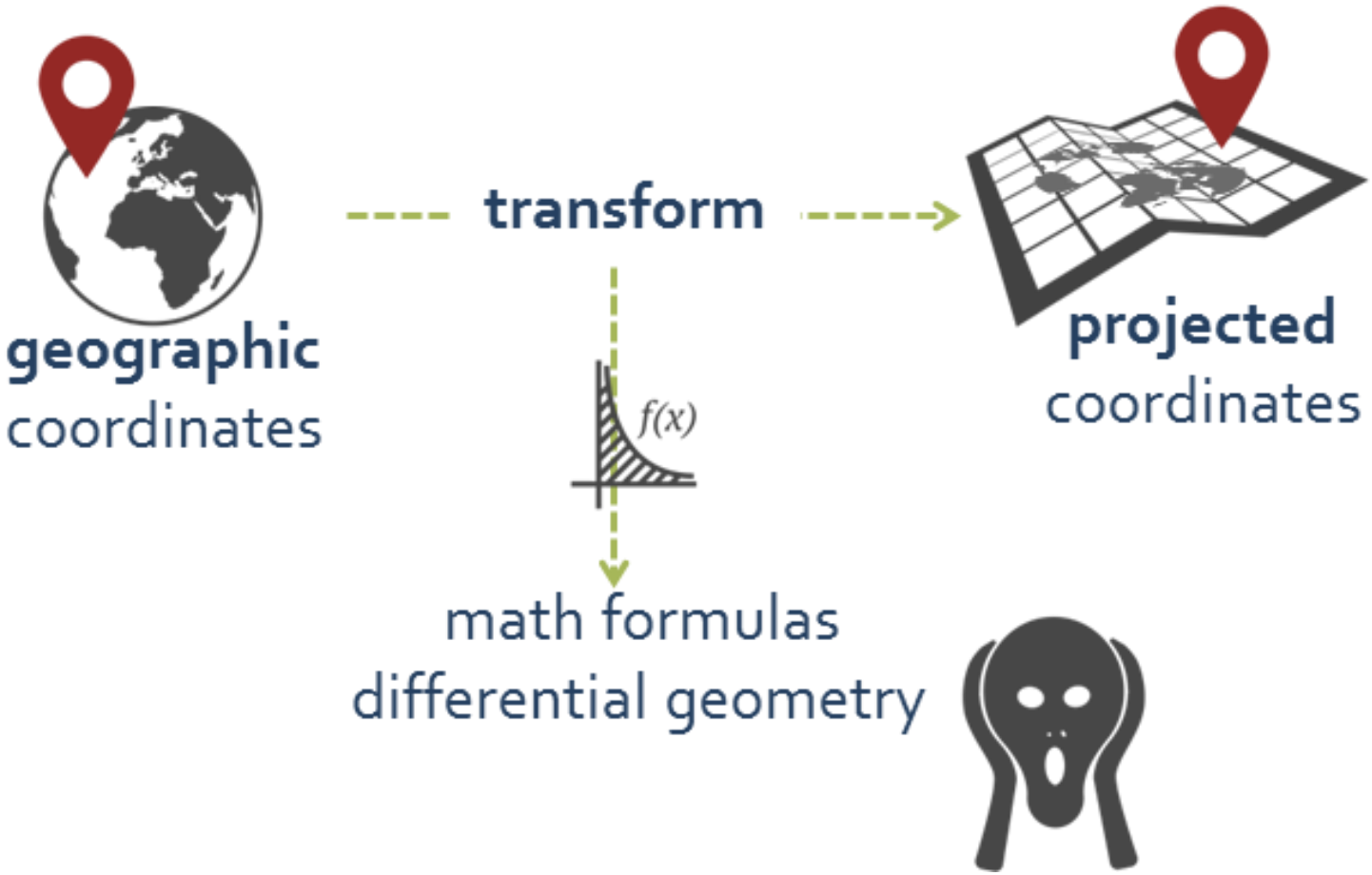
Coordinate reference system - projection



Coordinate reference system - projection



Coordinate reference system - projection



Coordinate reference system - projection

1 light classes

inside

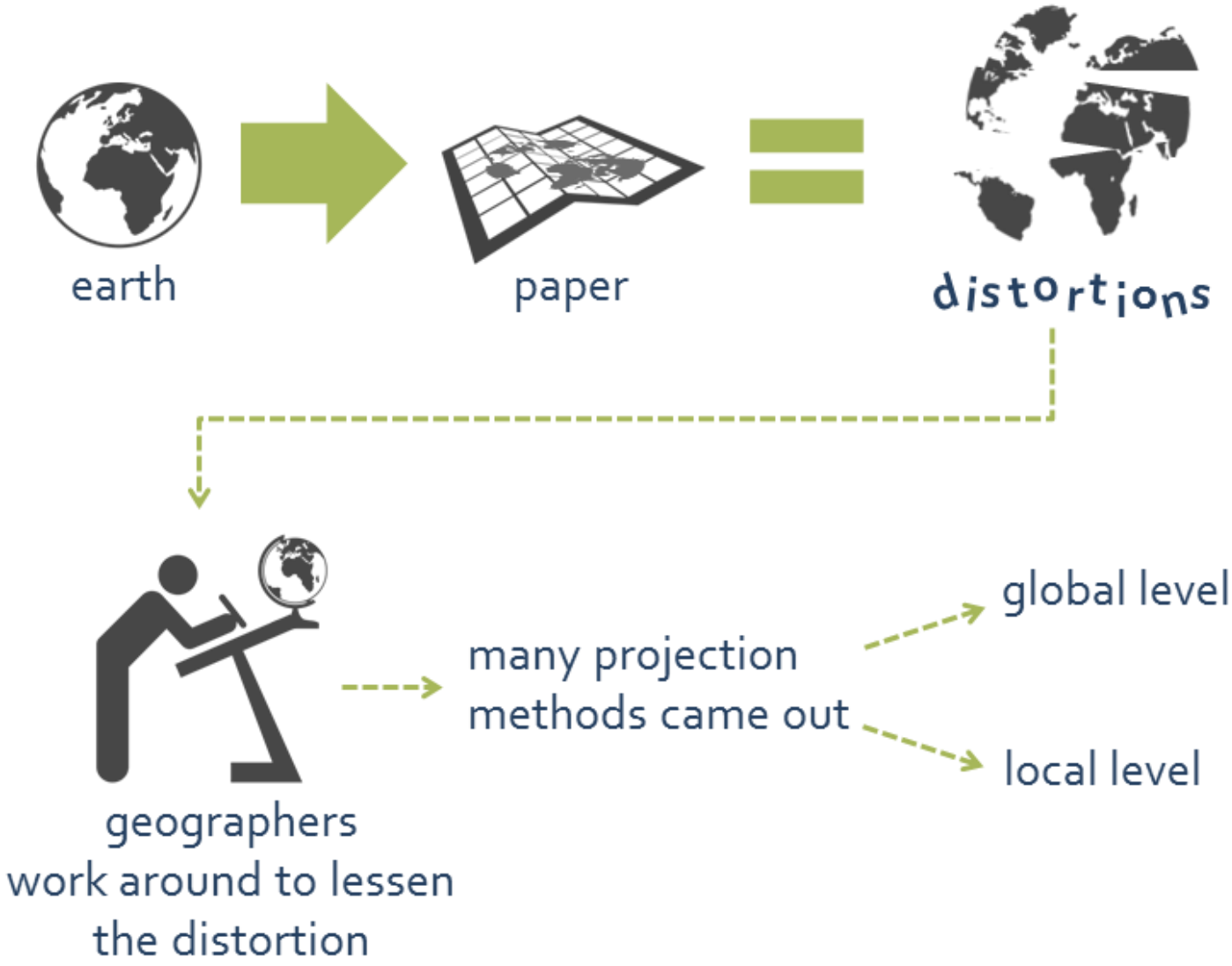
outside

2 developable surface

cone

cylindrical

Coordinate reference system - projection



Coordinate reference system - projection

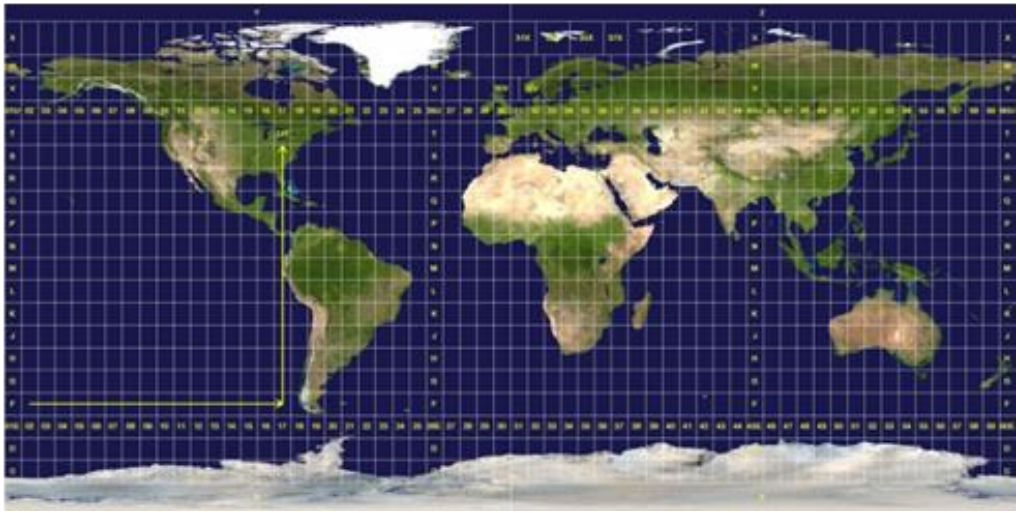
commonest
projected coordinate system

↓

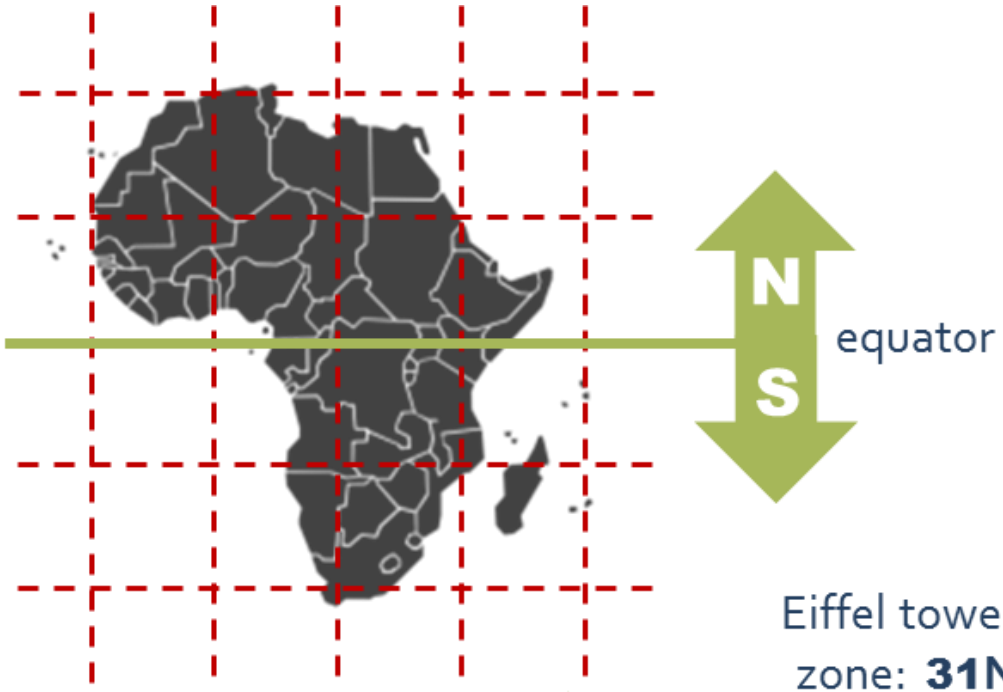
Universal **T**ransverse **M**ercator (**UTM**)

↓

- set of 6 degree wide zones
- 60 zone for global coverage



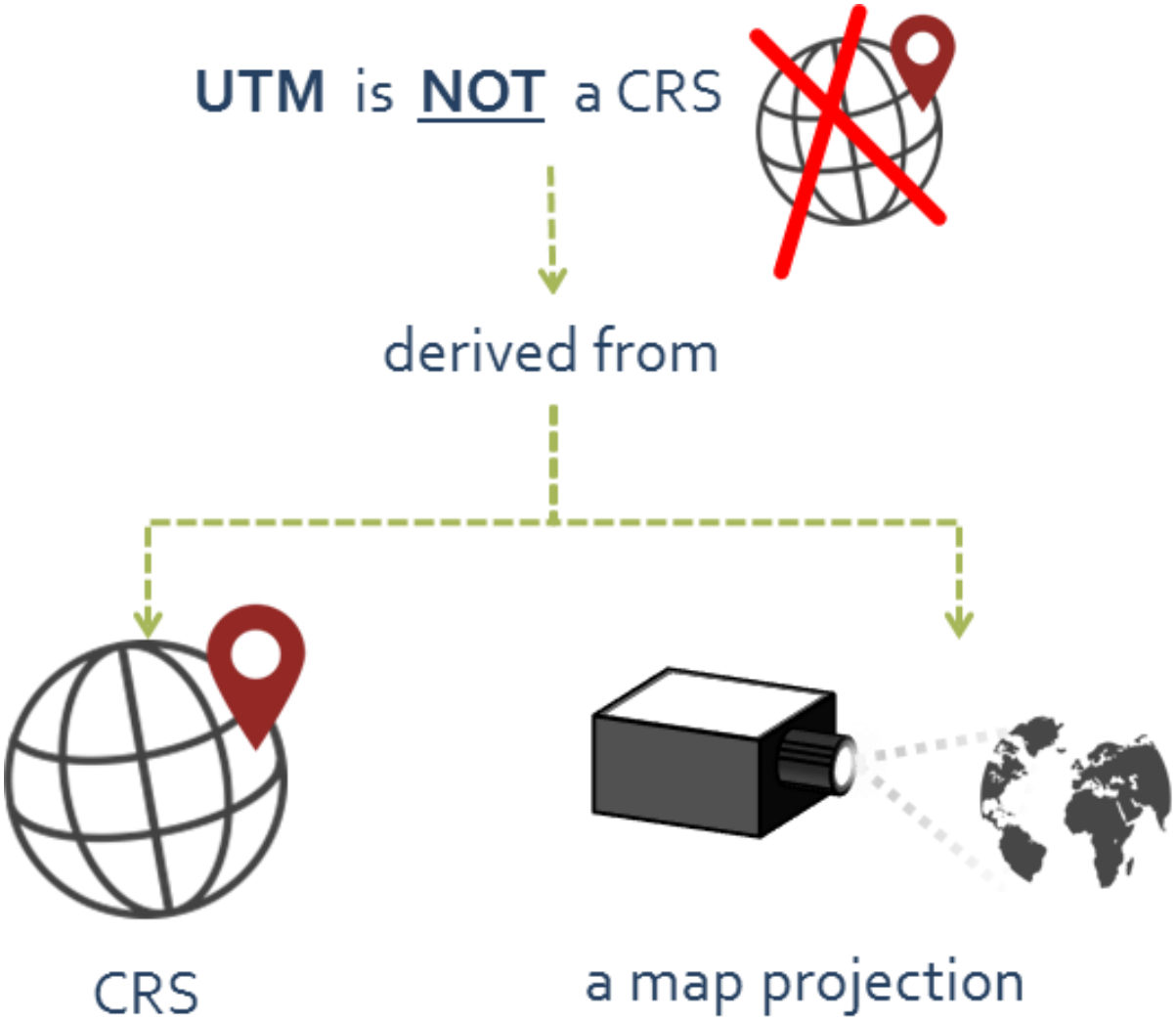
Coordinate reference system - projection



longitudinal
zone number

Eiffel tower
zone: **31N**

Coordinate reference system - projection



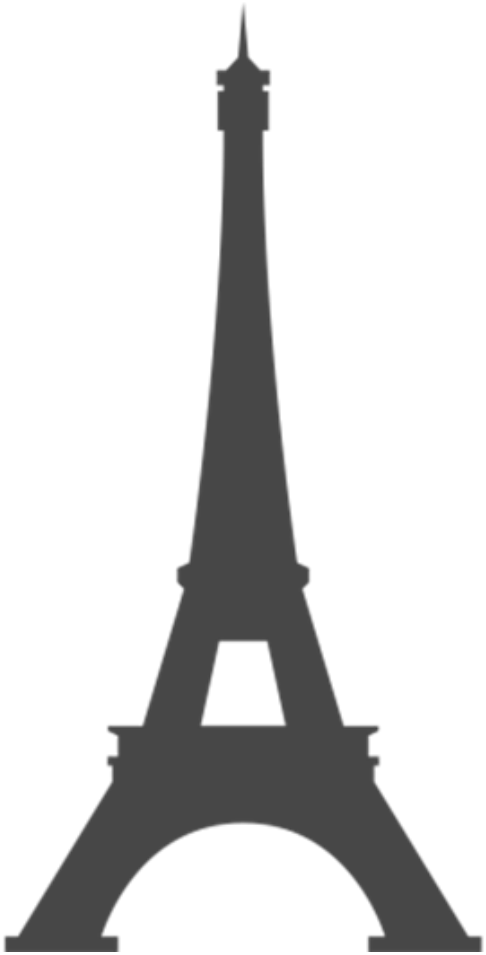
Coordinate reference system - projection

Eiffel tower coordinate

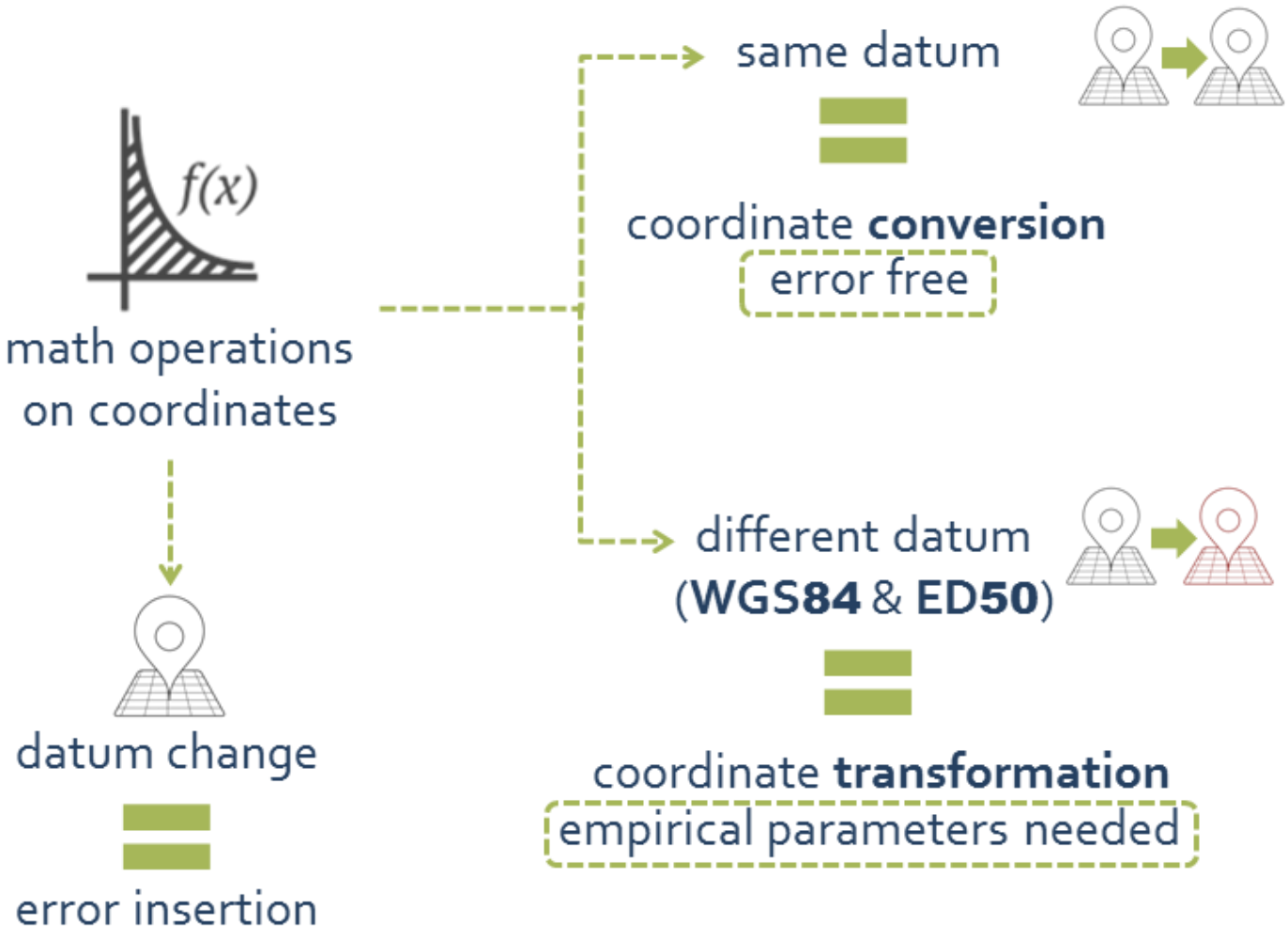
Zone 31U - E: 448250.58 N: 5411951.59

if the geodetic CRS is **WGS84**

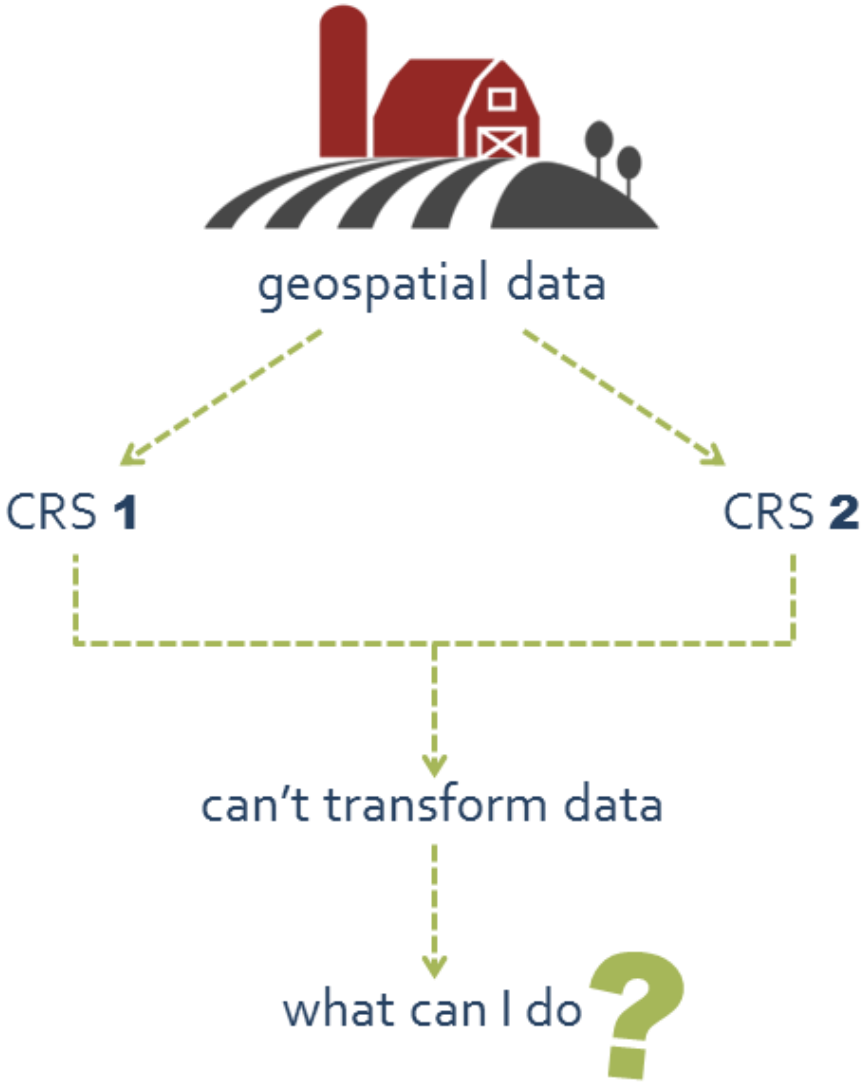
WGS84/UTM



Coordinate reference system - projection



Coordinate reference system - projection



Coordinate reference system - projection

many GIS include

on-the-fly projection

all data are displayed in the CRS defined

allows to overlay layers
referred to different CRS

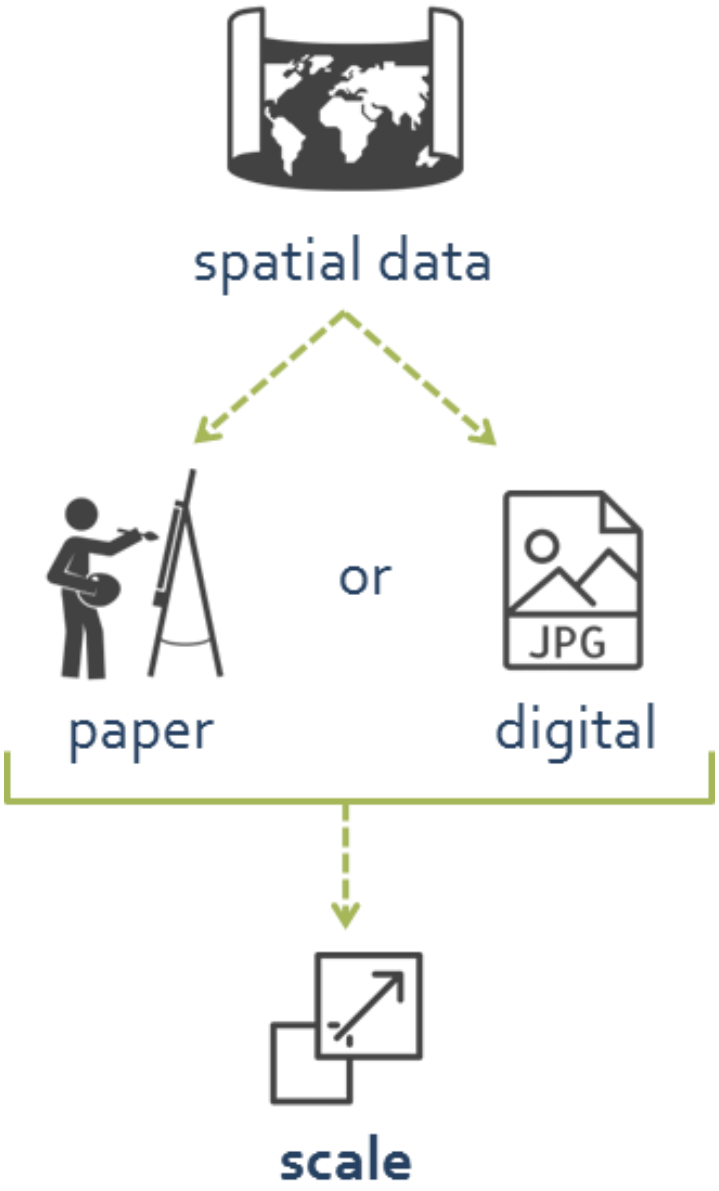
Take home message # 4

- Projection is a method used to transform angles in linear measure (meters)
- Projection introduce a distortion in the position
- UTM is the commonest projected coordinate system
  - uses x, y coordinates on 2D surface
  - citation implies CRS+UTM
- Different CRS? GIS can transform data on the fly

Coordinate reference system - projection

Questions?

Scale



Scale

scale

the **measurement of the amount of reduction**
of a feature represented in a **map**
respect to the **counterpart** on the ground

Scale

consider

all maps

→ an indicator of the map's scale

↓

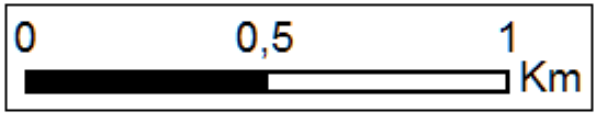
rapresentations of the **real world**

→ features are **reduced** in size when mapped

Scale

scale

1. graphic



2. verbal

*a **number** and **type** of unit measurement*

1 cm = 250 meters

3. representative fraction

ratio of map to ground measurement with a colon between the two measurements

1:25.000

Scale

what is the length of the coastline of Norway?

Scale

large
scale

small area

great amount of details

1:1000
1:5000

small
scale

large area

few details

1:1.000.000
1:10.000.000

Scale

details

large scale

small scale

features
more detailed

features
less detailed

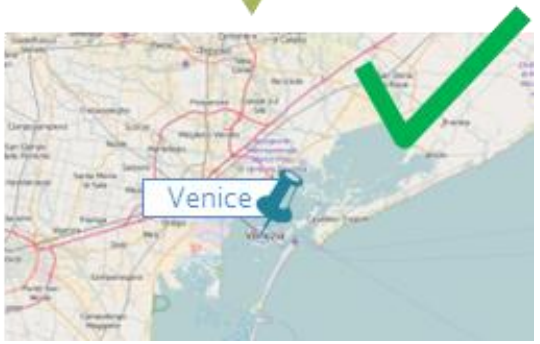
generalisation

Scale

same details
regardless map scale

noise level

- few details
- important details



Scale

working with large
scale and many details

↓

data capture

+

maintenance process

↓

requires time
depending on the
extension of the area

Scale

what is the length of the coastline of Norway?

1:50,000 map:
25,148 Km +
58,133 Km around islands
Total = 83,281 Km

Take home message # 5

1:1,000 1:5,000 1:20,000 1:50,000 1:250,000 1:1,000,000

LARGE MEDIUM SMALL

Features may disappear, e.g. ponds, hamlets, small lakes

Symbology for some features change, e.g. area to point

Features change in shape, e.g. become less detailed, more generalized

Some features may appear, e.g. macro features such as climatic zones

Scale

Questions?