Aalto University
School of Arts, Design
and Architecture

MAR-E1004 Basics of GIS: Georeferencing

Jaakko Madetoja
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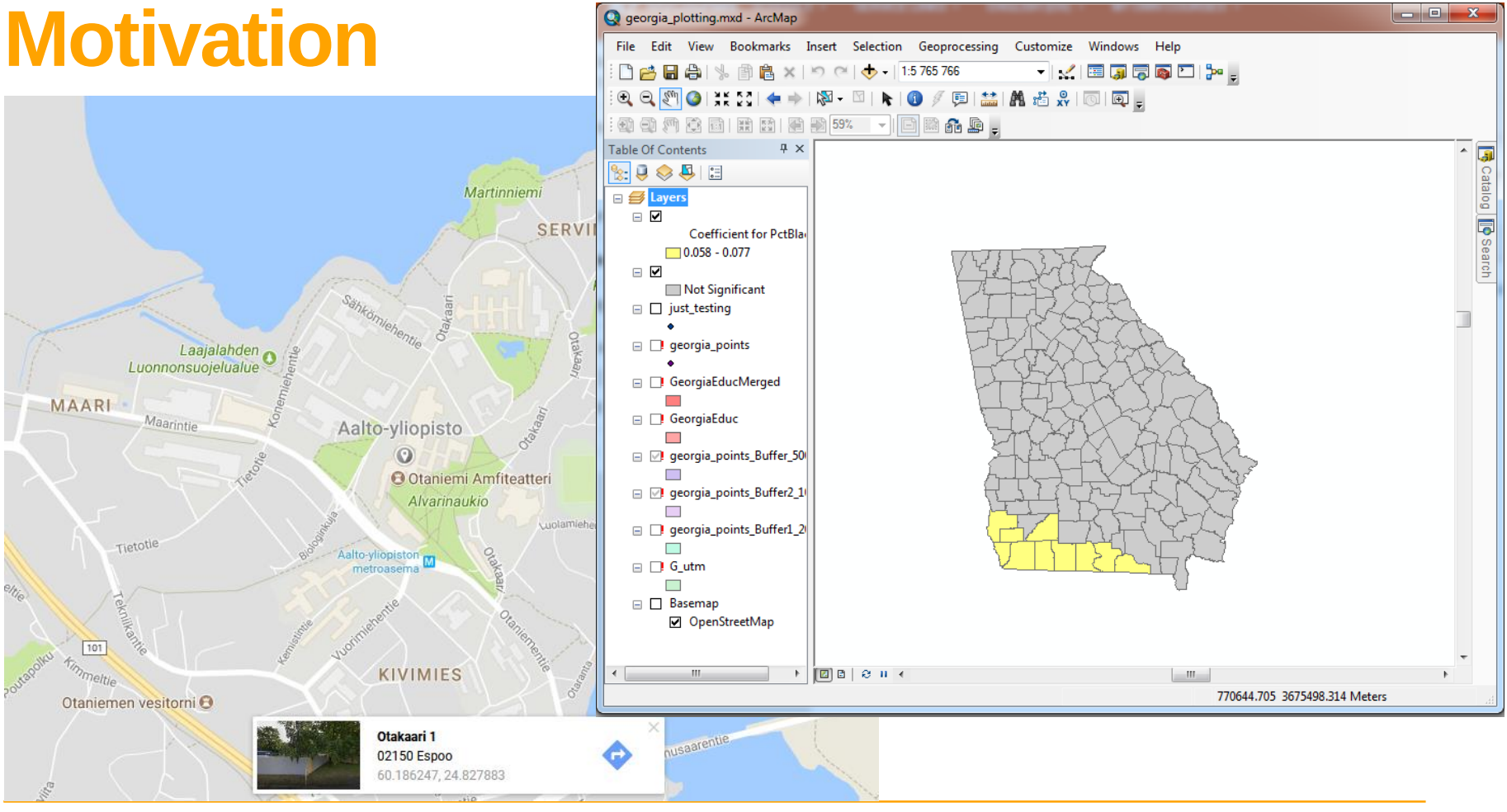
Slides adopted from Paula Ahonen-Rainio

Learning goals

In this session you will learn

- **To describe the basics of different types of referencing systems**
- **To explain the differences between geographical and projected coordinate systems**
- **To calculate and detect values of different projected coordinate systems**
- **To define and transform coordinate systems in ArcMap**

Motivation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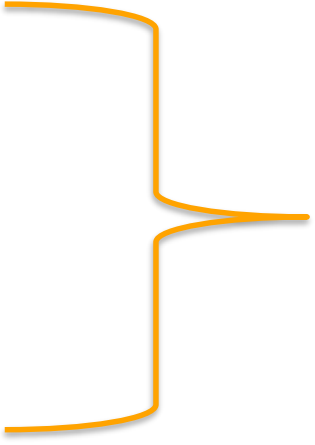
Otaniementie
KIVIMIES
Kimmeltie
Otaniemen vesitorni
101
Otakaari 1
02150 Espoo
60.186247, 24.827883

What is georeferencing

- **Georeferencing = to express a location on Earth**
- **Location has to be known in GIS**
  - We need a reference system to describe a location
- **Reference system has to be**
  - Unambiguous (to some extent)
  - Known to users
  - Constant in time
- **Properties of reference systems:**
  - Accuracy of positioning
  - Type: Metric (distances), ordinal, or nominal

Different types of reference systems

- Place names
- Street addresses
- Identification system
- Coordinate system



Discussed only shortly, because they are rarely used in a GIS

Place names

- **Common in every day positioning**
- **Names often commonly known**
  - Some can be only locally known
  - Same name for different places; ambiguous
- **System scales really well**
  - From continents to small villages
- **Changes (slowly) in time**

Example: Place names

MML (Paikkatietoikkuna)

Street addresses

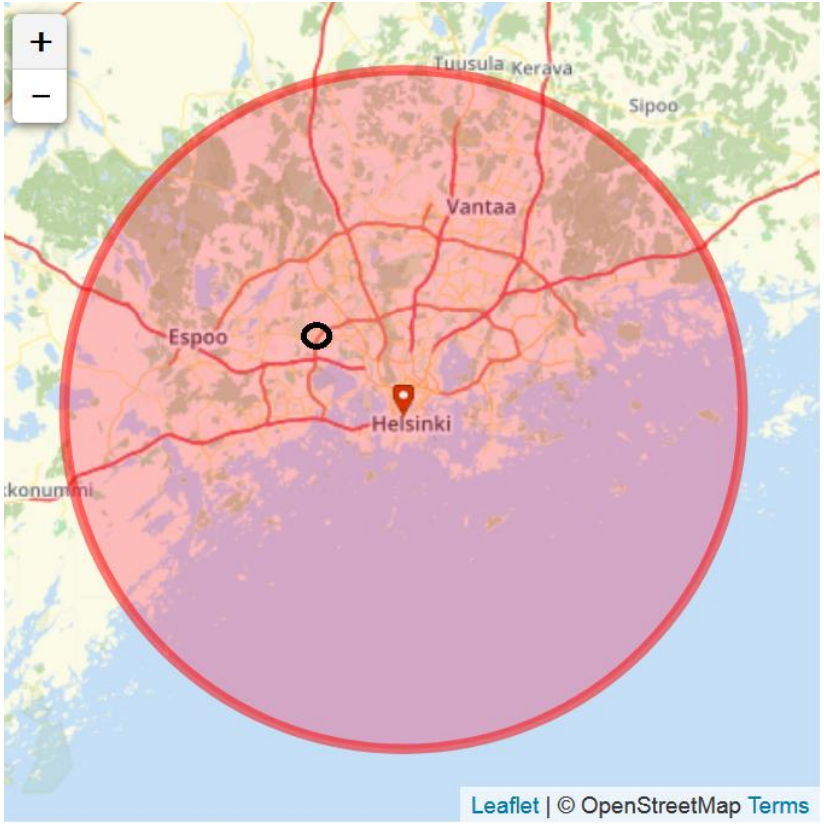
- **Address + municipality is unique**
  - Buildings are numbered along a road: Ordinal scale
  - In country side, address number is distance to the start of the road
- **Exist only for built environment, not for natural areas**
  - Lakes, islands, hills, mountains, rivers…
- **Postal code areas**
  - Unambiguous, reflect the distribution of population
  - Hierarchical: first numbers describe larger areas, the following smaller
- **Geocoding: transforming address to coordinates**
  - Requires a reference system, e.g. coordinates linked to address in a register
  - Can be done in ArcMap; uses “ArcGIS Online World Geocoding Service”

Identification systems

- **Real estate identifier**
  - Every real estate and parcel has one
  - Hierarchical and unique in Finland
- **Grid identifier**
  - E.g. rescue service grid
  - Grid size defines the accuracy
- **IP addresses**
  - Can be used for geocoding, if the address for the user is known
    - Accuracy varies

Example: Geocoding based on IP

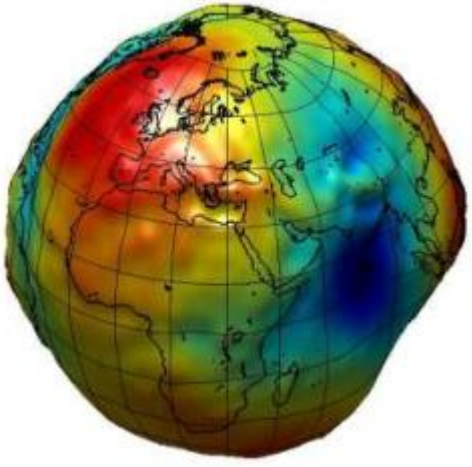
I live in Leppävaara, Espoo



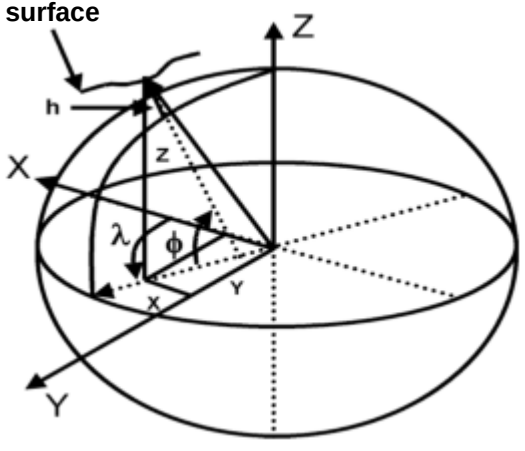
Coordinate systems

- **Metric: Distances and directions**
- **Standard definitions, unambiguous**
- **Tied to the surface of Earth with benchmarks (kiintopiste)**
- **Transformations and conversions possible**
- **Stabile: Only small changes in time**
  - Tectonic plate movement, upthrust (maannousu), major earthquakes

Starting point: Earth



- Geoid (geoidi), i.e. ocean level, is bumpy and slightly flattened ball
- It is replaced by regular shaped ellipsoid in calculations
- Ellipsoid is placed in the center of Earth and tied to rotation creating a reference system
- Location is reported using geographic coordinates latitude, longitude and height (ϕ, λ and h)

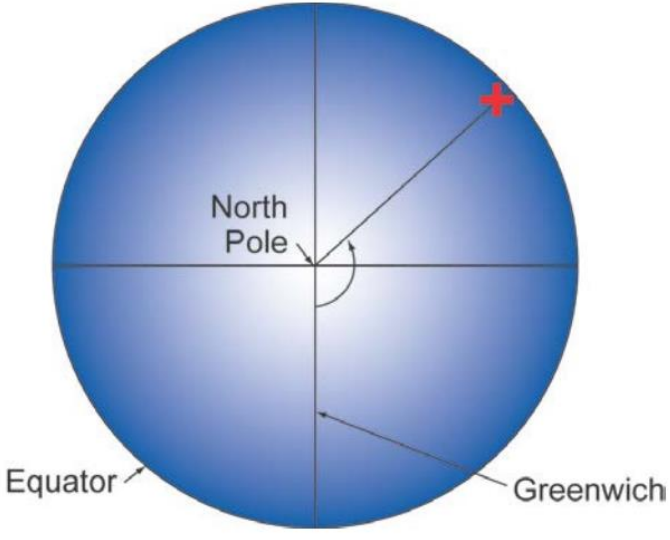


Longitude (pituusaste)

Specifies the east-west position; the angle between a meridian and the Prime Meridian (λ) (East/West [0..180º])

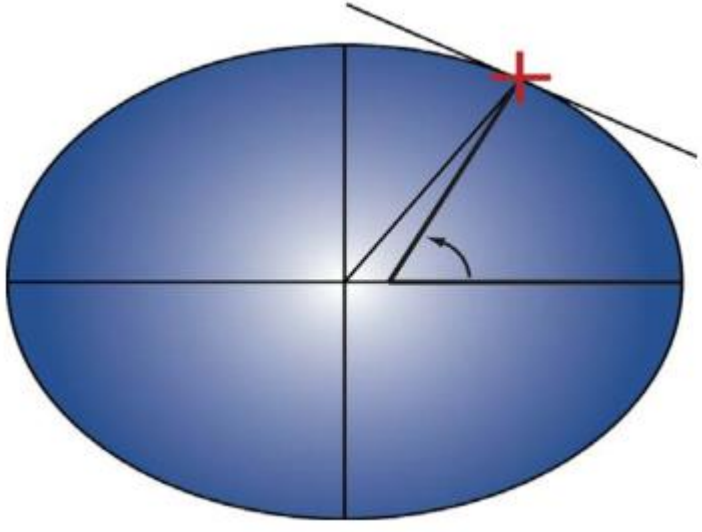
Meridian (pituuspiiri): great circle running through poles

Prime Meridian: meridian running through Greenwich



Latitude (leveysaste)

Specifies the north-south position; the angle between a normal of an ellipsoid and the equator plane (ϕ) (North/East [0..90º])



Geographic coordinate systems

- **Different systems are based on different ellipsoids and center points**
  -> Same coordinates point to different places in different systems

- **Transformations between systems possible**
  - This is often automatic in GIS assuming each layer has its real system defined and parameters are correct

Note: Always set the coordinate system of a layer to the correct one (found from metadata)!

- **Most common geographic coordinate system is WGS84 (used in GPS)**

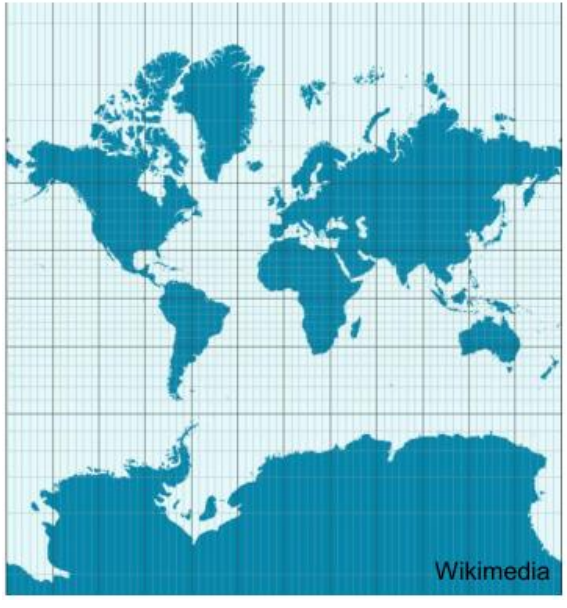
Projection from ellipsoid to a flat plane

- **Multiple reason to use plane coordinates (east, north) instead of angles:**
  - Easier to measure and calculate distances
  - Maps are shown on paper or screen (both planes)
  - Raster is a plane; difficult to create a raster on curved surface
  - Visualizing the Earth all at once can only be done when projected

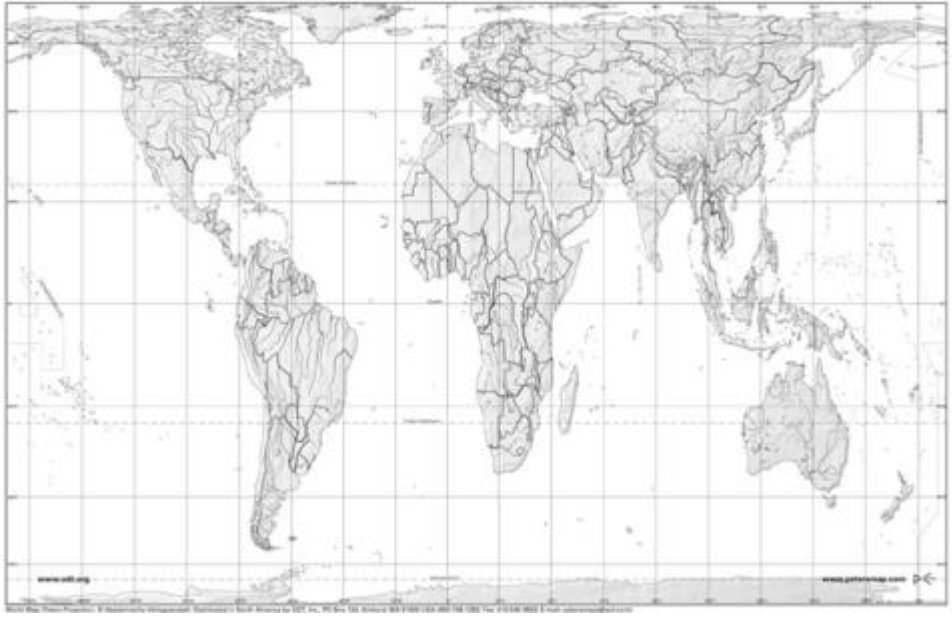
- **Projecting a curved surface to a plane always causes deformations:**
  - *Conformal* projections preserve shapes and angles
  - *Equivalent* projections preserve areas and area ratios
  - *Equidistant* projections preserve distances between points

Example: Conformal and equivalent projections

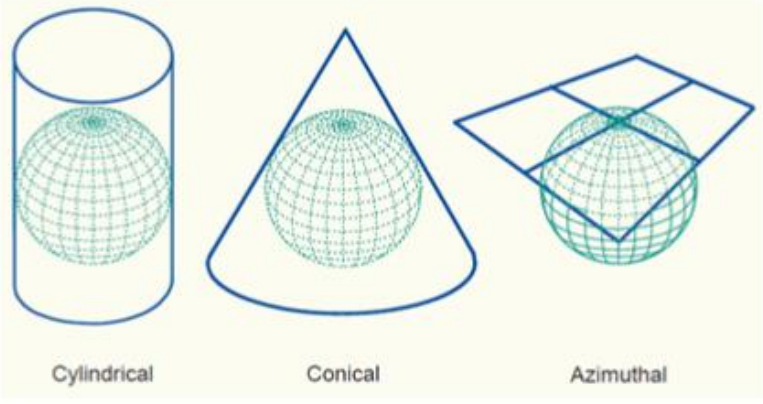
Mercator (conformal)



Peters (equivalent)



Projections



cylindrical projection = lieriöprojektio

conical projection = kartioprojektio

azimuthal projection = tasoprojektio

sivuava = tangent

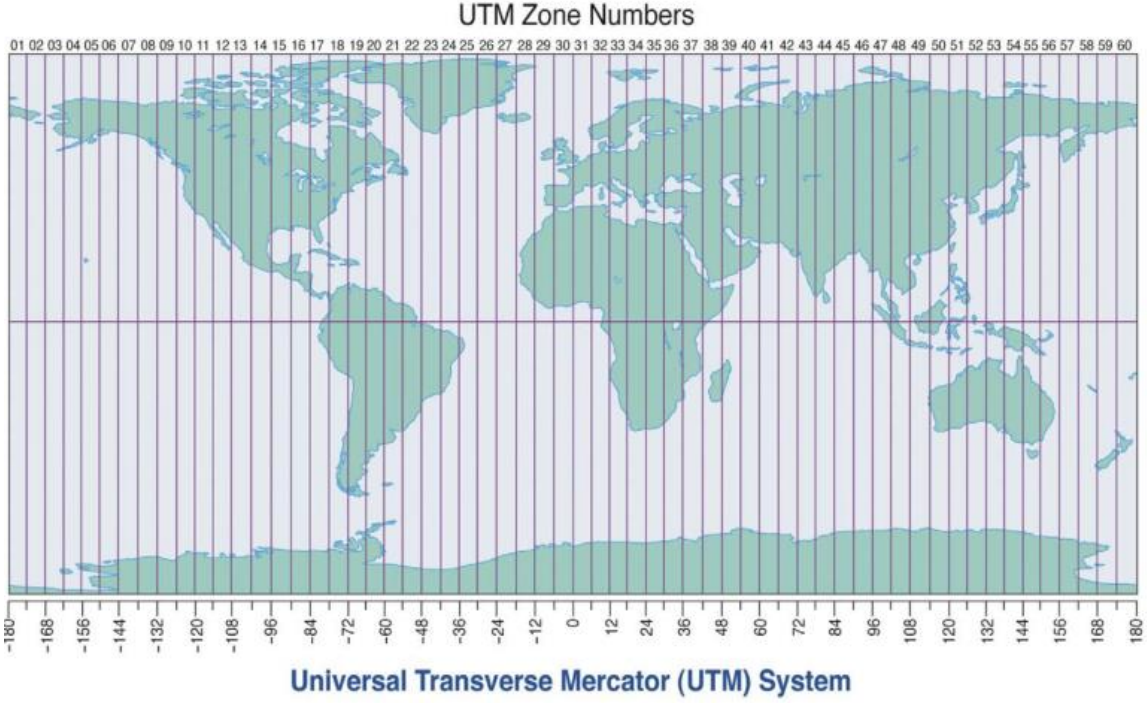
leikkaava = secant

Using zones in projected coordinate systems

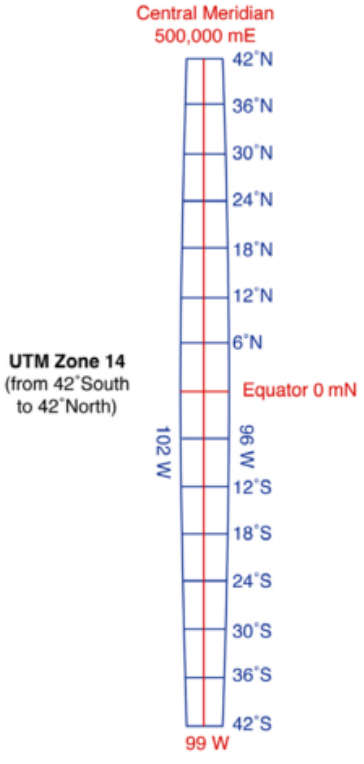
- **Motivation: Projected coordinate systems are accurate only along a thin strip**

- **Zonal projections: Divide the whole area (continent, country) in zones (thin strips) and use a separate projection and coordinate system for each**
  - Coordinate values are not continuous when moving from one zone to another; need conversions

Zones in Universal Transverse Mercator (UTM) system



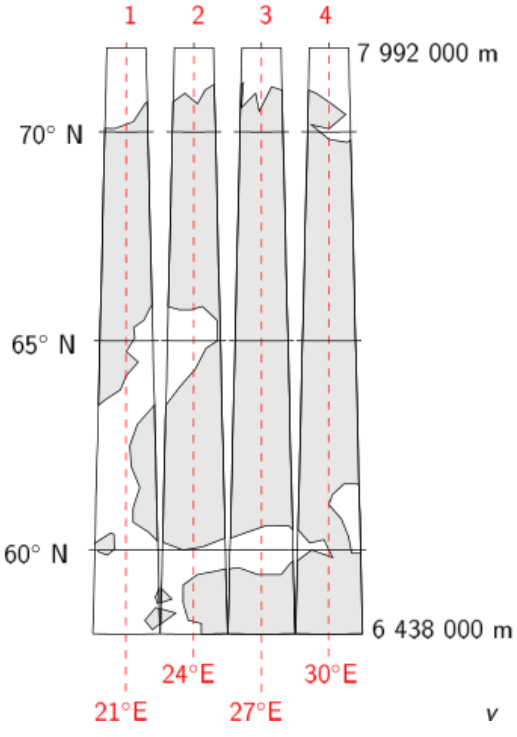
UTM coordinates



- **North coordinate (N) is measured from the Equator**
- **East coordinate (E) is 500 000 m in the central meridian**
  - This is to avoid negative coordinates
- **Finnish version, ETRS-TM35FIN:**
  - ETRS refers to ellipsoid ETRS89 (or EUREF-FIN)
  - TM35 (Transverse Mercator) zone number 35
  - FIN refers to special conditions made: wider zone than normal

Previous system in Finland: kkj (kartastokoordinaattijärjestelmä)

- **4 zones, central meridians 21, 24, 27, 30º**
- **Zones numbered 1-4**
- **North coordinate from the Equator**
- **East coordinate: zone number x 1000 km + 500 km:**
  - E.g. 2 650 000 is in zone 2, 150 km east from the 24º meridian



Coordinate systems in ArcMap

- **kkj# is Finland Zone #; kkj3 is most often used for the entire data set**
- **ETRS-TM35FIN is sometimes found as EUREF-FIN**

- **The map view has its own coordinate system! It is automatically chosen as the first added layer; can be modified by right-clicking Layers in Table of Contents**

Switch to ArcMap

- Open a new document (File -> New) to ensure the map view has no coordinate system
- Add layers buildings.shp and postal_code.shp (note that they are missing the .prj-file!)
- Where are the data sets located in the map view? Use Zoom to Layer to find out (right-click the layer). What can you say about the coordinate systems based on the values shown in the lower right corner of the map view?
- Delete both layers from the view and open Catalog from Window -> Catalog. From there you can change/set coordinate systems by right-clicking a layer -> Properties -> XY Coordinate System
- Set WGS 1984 (Geographic -> World) for the buildings and ETRS 1989 TM35FIN (Projected -> National Grids -> Finland) for the postal code areas
- Add the layers now to the map view (note how the .prj file has appeared). You might also need to set the projection for the map view by right-clicking the Layers in Table of Contents

Coordinate transformation in ArcMap

Setting the coordinate system to a different does not transform the coordinate values!

Easiest way to transform coordinates for a layer is setting a desired system to map view (right-click Layers…) and exporting data (right-click the layer, Data -> Export Data) with the option "Use the same coordinate system as: the data frame".

Try transforming the buildings to ETRS 1989 TM35FIN system.

No homework this week!

The topic Modifying data includes homework, but it is moved to session 3.