Visualisation techniques AG2412

a course given by
Division of Geoinformatics
Department of Urban planning and Environment
Royal Institute of Technology

Visualisation techniques AG2412

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Visualisation techniques

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Visualisation techniques AG2412

Course curricula: lectures

L1: Introduction to cartography and geovisualisation
L2: Visual perception and cognition
L3: Graphic variables and map design
L4: Thematic mapping
L5: Visual data mining and exploratory data analysis
L6: Maps and geovisualisation as decision tools
L7: Web cartography
L8: Mapping time
L9: IT industry application: hitta.se by Starcus

Visualisation techniques AG2412

Course curricula: exercises

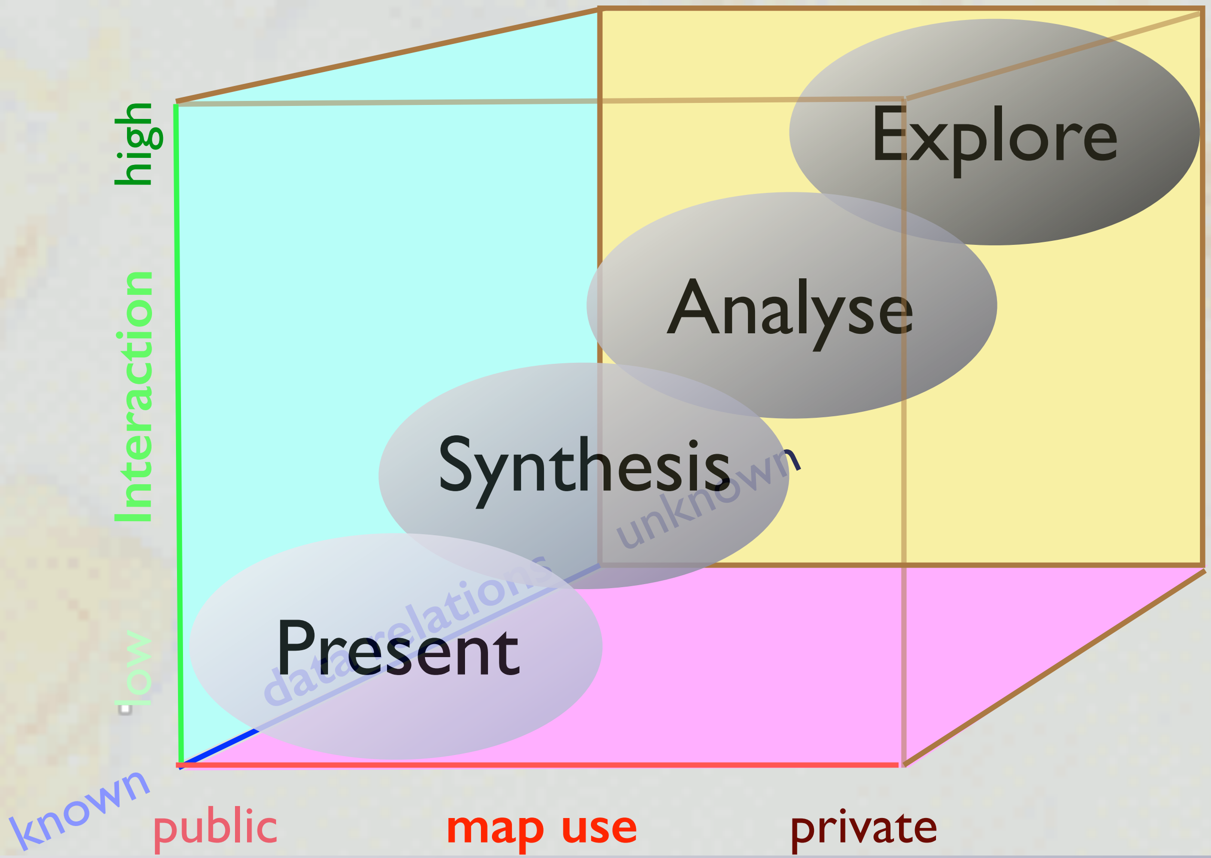
E1: Introduction to the mapping software (ArcMap)
E2: Designing cartographic symbols (design exercise)
E3: Analysis of thematic maps (self-study exercise)
E4: Designing thematic maps (computer lab)
E5: Interactive maps and data mining (computer lab)
E6: Visual data analysis (computer lab)
E7: VRML (computer lab)
E8: Geovisualisation project

A written report (details in the instructions for each exercise) has to be submitted after every exercise in order to have the exercise approved.

NO COPYING!!!!!!!!!!!! From others or from internet.

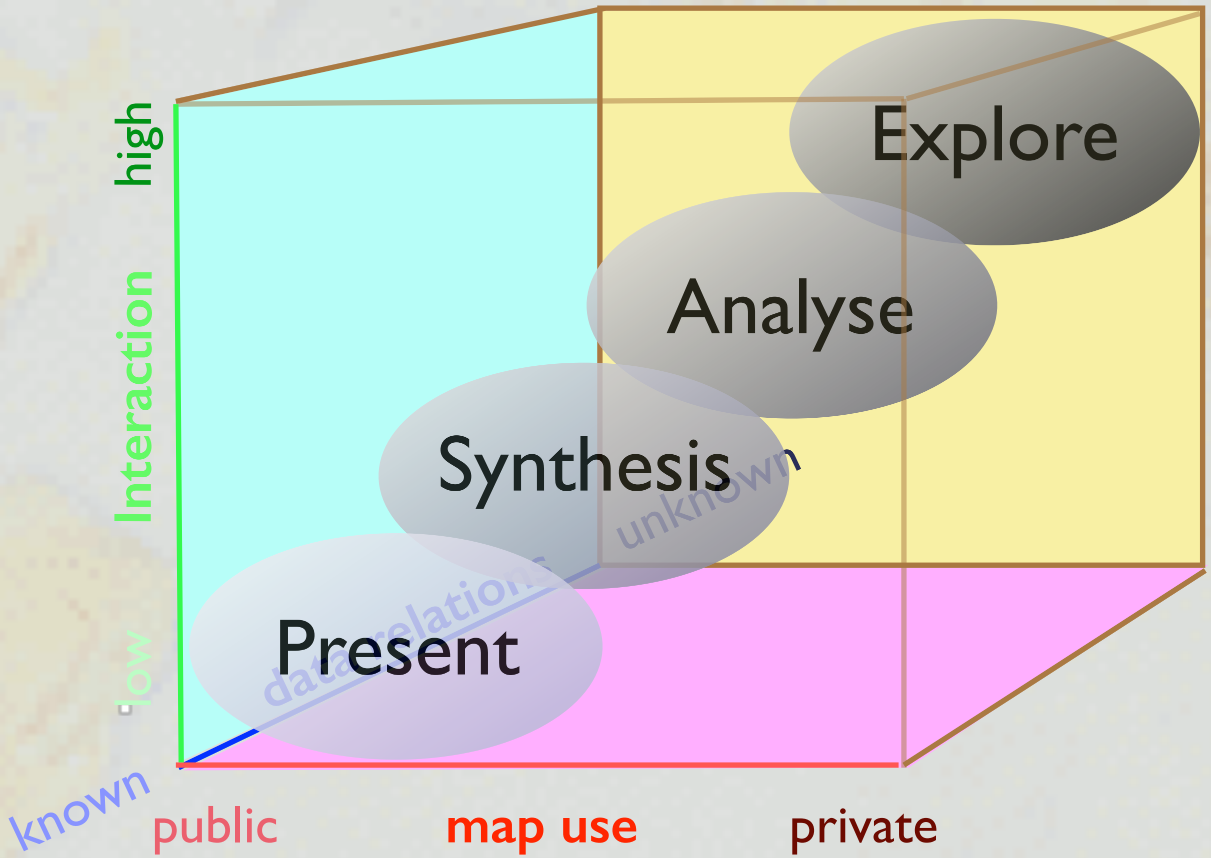
The last day for submission of the report is specified on the exercise form. Submission date is counted as approval date.

The map use cube (MacEachren and Taylor, 1994)



The most advanced electronic atlases and GIS softwares can be used to explore (e.g. visually, statistically) geographic data for private use with high interaction and unknown relations

Geospatial Data Infrastructure (GDI)



Example 4

Baltic Google Earth Atlas

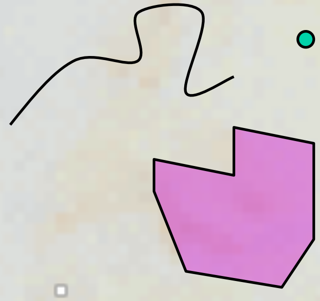
Geospatial data

Geospatial data → Location, attributes & timing of an object or a phenomena on the Earth

Digital Landscape Model (DLM)

Abstractions of the real world

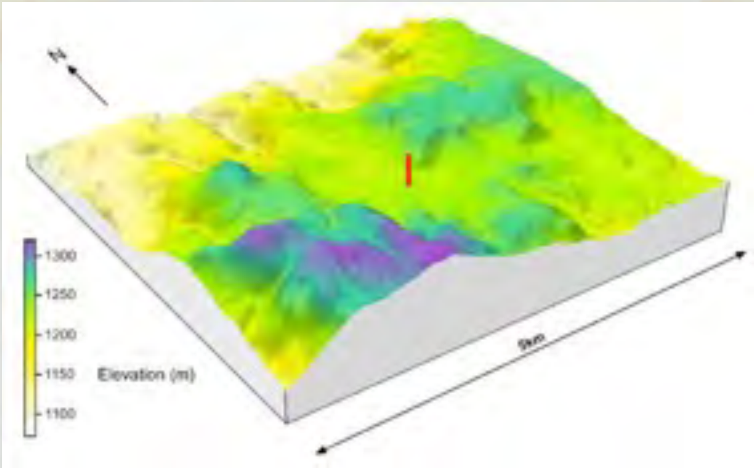
Discrete objects



Border

Explicit location

Continuous representations



Measurable

Based on models

Digital Landscape Model (DLM)

- **Geospatial data**
  - Geometric data
    - Location
    - Dimensions
  - Attribute data
    - Quantitative
    - Qualitative
  - Temporal data
    - Moment in time when geometric and attribute data are valid

Attribute data scales

Measurement scales for attributes

- Nominal scale → Languages: English, Swedish, German, Spanish
- Ordinal scale → Climate: hot, warm, moderate, cold
- Interval scale → Temperature: ºC or K scale
- Ratio scale → Population density: no. of inhabitants/km^2

Data capture: from DLM to GIS

Ideally all the different geospatial data should be:

- collected at the same time,
- with the same spatial resolution,
- according to the same procedures and
- pre-processed for the use with GIS using the same methods.

Data capture: from DLM to GIS

But in reality the data are collected:

- at different points in time,
- valid for different spans of time,
- at different spatial resolutions,
- are obtained from different sources,
- pre-processed using different procedures.

↓

Information about data acquisition is important in order to be able to know something about the uncertainty and quality of data. This **uncertainty** propagates through data analysis and is present in the results.

Data capture: from DLM to GIS

Data quality

Every product of data integration has a certain level of uncertainty due to:

- Mistakes in original data
- Data processing

Data product is usable only when a cetrain level of reliability is reached.

Important: to present information about the quality of original data and the uncertainty from the processing steps to the user.

Data capture: from DLM to GIS

Aspects of data quality:

- Lineage – when the data was collected, what processing was used, etc.

- Positional accuracy – how far is an object from its real position

- Attribute accuracy – what is the accuracy of attributes' values for an object

- Logical consistency – do the lines intersect in a point, are the areas closed polygons, etc.

- Completeness – is the data complete for the whole collection area

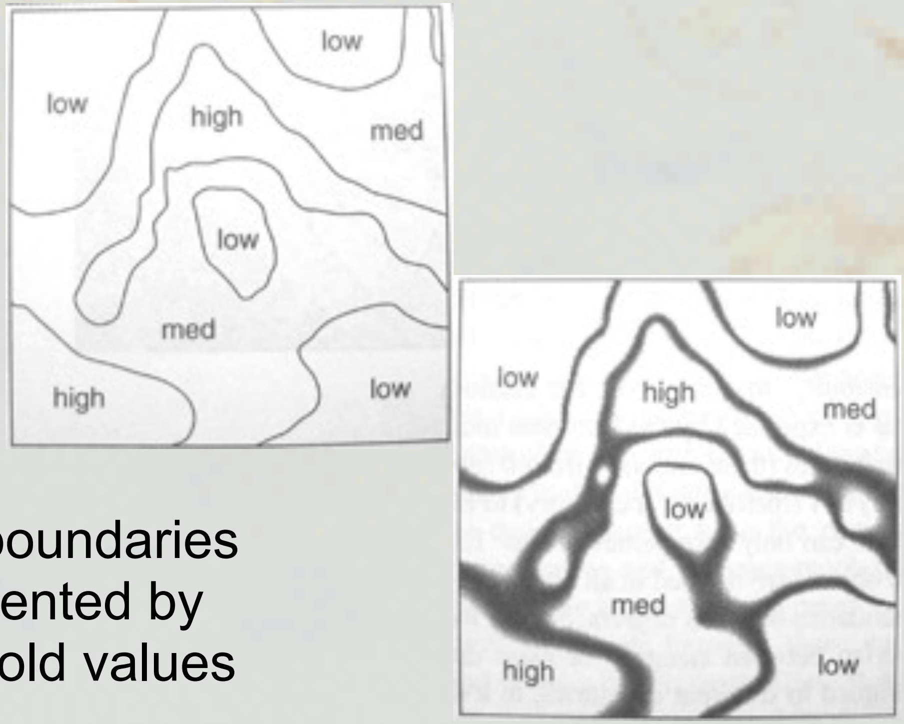
Data capture: from DLM to GIS

Visualising uncertainty

Probability maps

Maps of maximum likelihood, second likelihood, or a change between maximum and second likelihood

Fuzzy maps



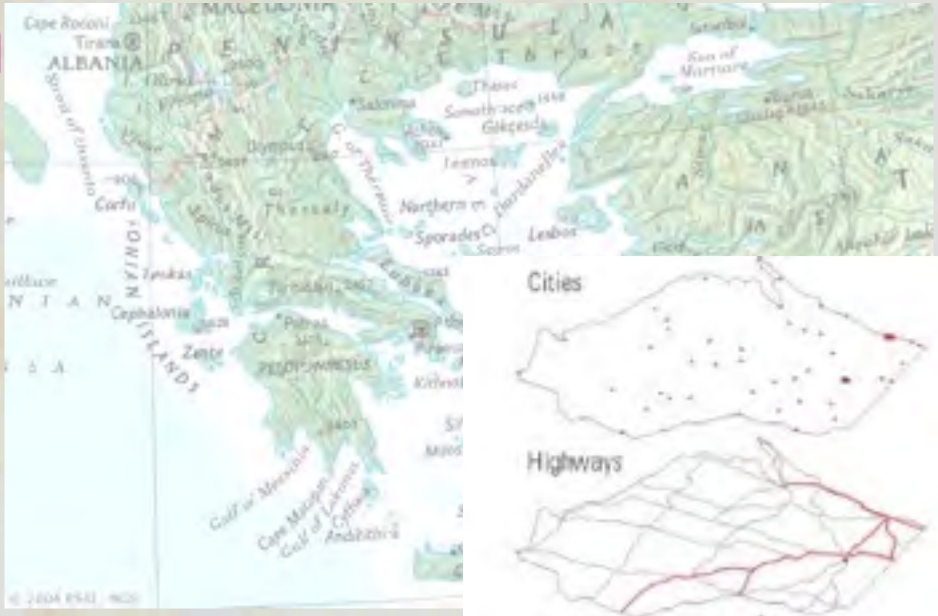
Area boundaries represented by threshold values

Data capture: from DLM to GIS

Main sources of geospatial data:

- terrestrial surveys,
- remote sensing data (aerial and satellite imagery),
- GPS data,
- digitising or scanning existing maps,
- socio-economic and statistical data,
- physical data,
- environmental data.

Maps and GIS – Cartography and Geovisualisation

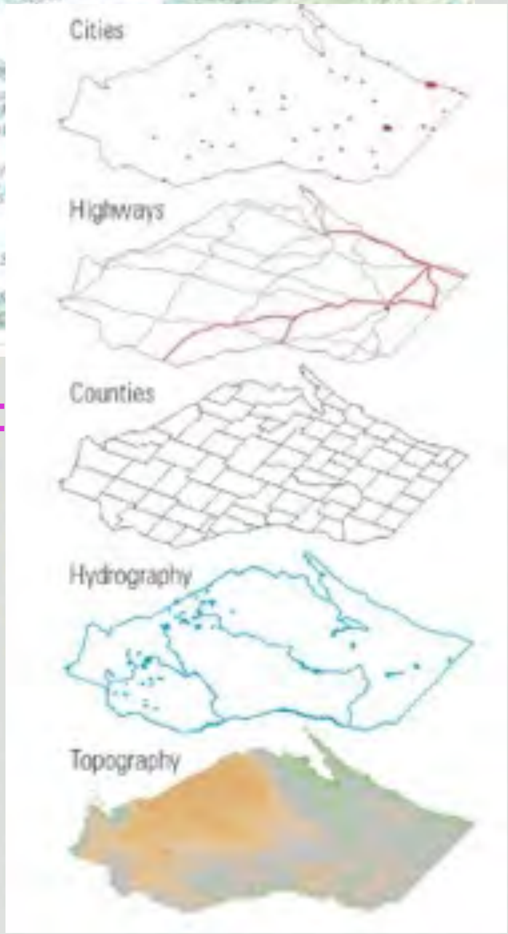


The purpose of maps:

- to visualise geospatial data

- to show geospatial relationships

The purpose of Geographic Information Systems (GIS):



- to integrate and combine geospatial data from different sources

- to manipulate, analyse and visualise the combined data

Cartography

Cartography

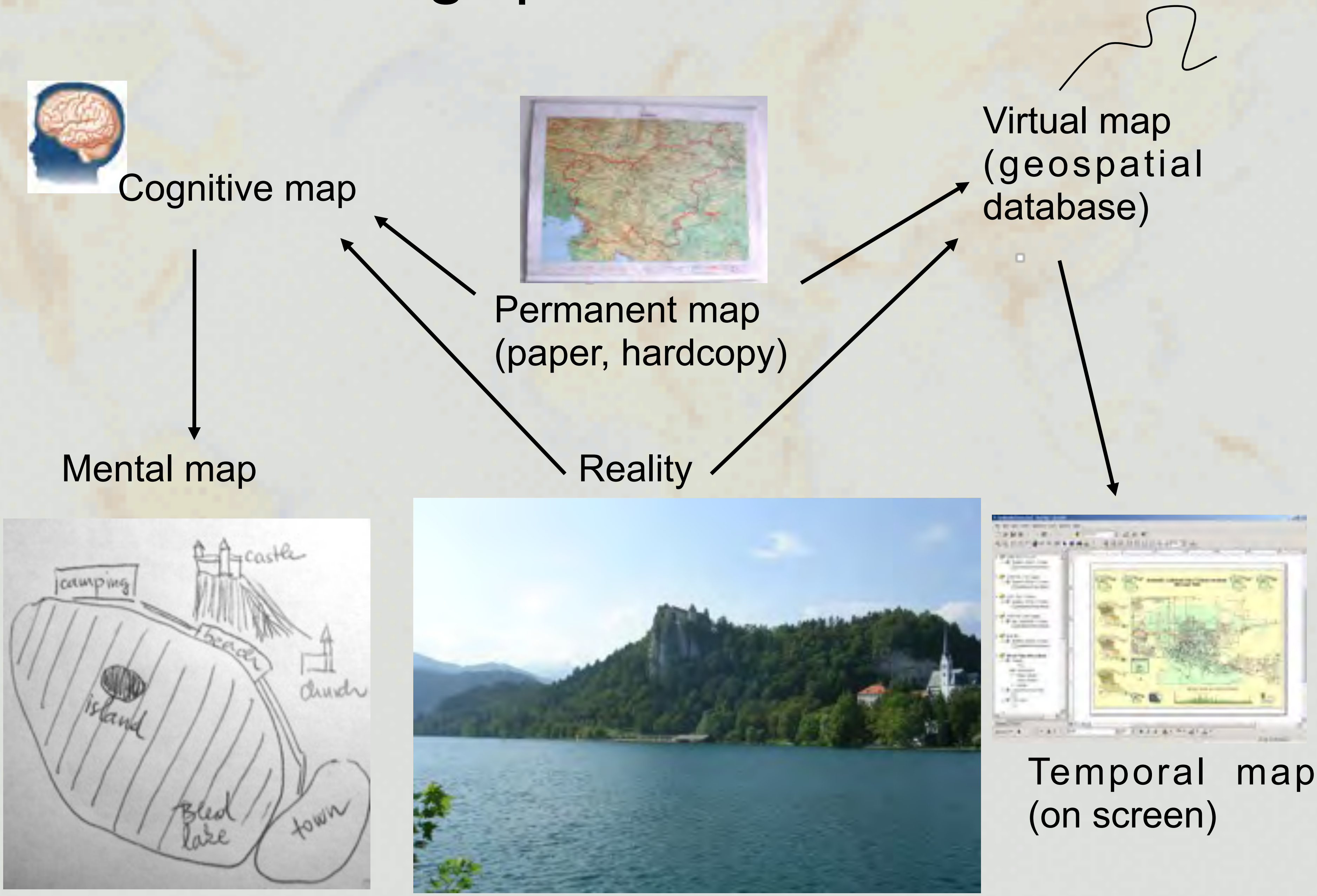
Cartography:

Definition until 1960s: ”manufacturing of maps”

↓ computers

Cartography includes organisation, presentation, communication and utilisation of geospatial inforamtion in graphic, digital or tactile form. It includes all stages from data preparation to end use in the creation of maps and related spatial information products.

Cartographic communication



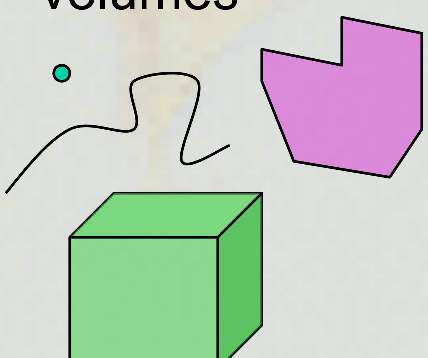
The visualisation process

Reality

Model construction – object selection

Digital landscape model

Points, lines, areas, volumes



Select & construct geographic representation

Digital cartographic model

Drawing code for objects, cartographic rules

Medium output

Visualisation or map: paper/on screen

Cognitive map

Geovisualisation

Geovisualisation

Geovisualisation is a domain that addresses the visual exploration, analysis, synthesis and presentation of geospatial data…

↓

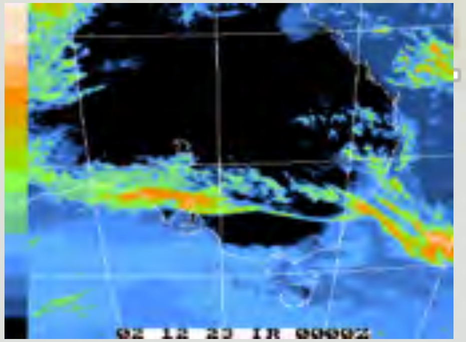
…by integrating approaches from cartography with those from scientific visualisation, image analysis, information visualisation, exploratory data analysis and GIScience.

Maps

Paper → Storage and representation of geospatial data

On-screen → Application of database technology and computer graphics – new alternative presentations and visualisations:
3D, animations

On-screen → Geospatial analysis



Roles of geovisualisation

Access to data

Easier access to databases behind the maps

Exploration

Explore raw data to find spatial patterns

Presentation

Communicate geospatial knowledge to an audience

Analysis

Manipulate known data to show relationships and discover connections

Early cartography

Ptolemaios created a world map around 100 A.D, which reached Europe via Bysantium and was printed in 1477 in Bologna.

Scandinavia is shown as a small island (Scadia).

Early cartography - Scandinavia 1430

Claudius Clavus (i.e. Claus Svart in Danish) created a better map over Scandinavia around 1430. This is printed in Ulm 1482, as part of Ptolemaios atlas.

Early cartography - Scandinavia 1536

Map by J. Ziegler printed in Strassbourg 1536, as part of a larger work over the Holy Land. Sweden mapped out by the last catholic arch-bishop of Sweden - Johannes Magnus.

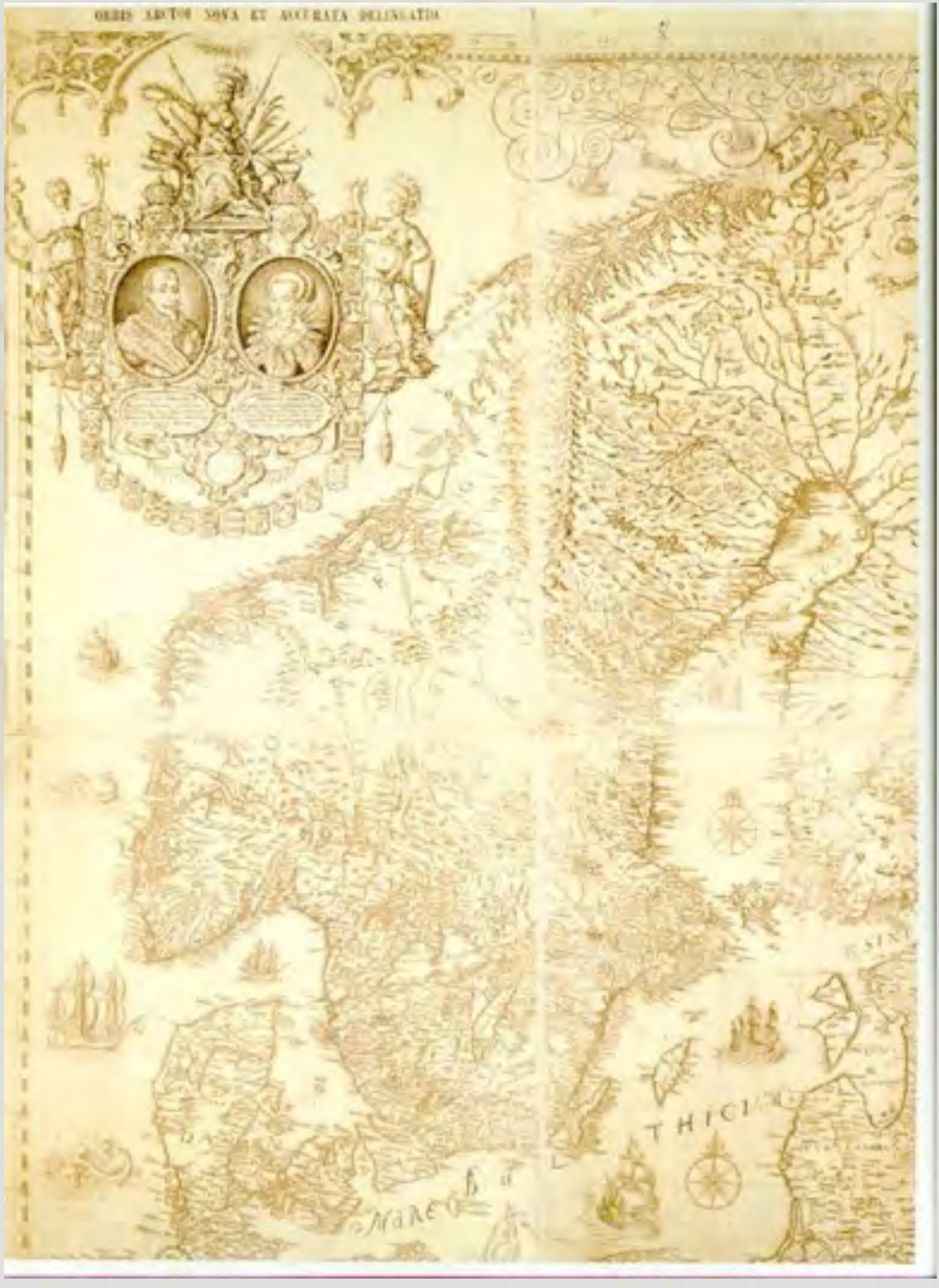
Early cartography - Sweden 1530

Carta Marina

Made by Olaus Magnus (brother of Johannes) who surveyed Sweden for Gustav Vasa and then finalised the map in Rome 1527-1539. Printed in Venice 1539. Two known copies have survived, found 1886 in Munich and 1960 in Switzerland. The latter bought by Uppsala university in 1962.

Early cartography - Lantmäteriet founded in 1628

Andreas Bure, created lantmäteriverket by orders from Gustav II Adolf in 1628. He also made this map, in 1626.



Early cartography - 1688 map of Sweden

The first general map based on more modern cartographic symbolisation was presented by Lantmäteriverket in 1688, scale 1: 3 M.

Visualisation was for highlighting tactile geographic (not religious, cultural or genealogical) features.

mapjourney.com

Early cartography - 1747 map of Sweden

Lantmäteriverkets map from 1747 was the in the scale 1:2 560 000, and visualised administrative (political) features and tactile geographic features (hydrography, infrastructure). This map was sold to the general public.

Early cartography - 1797 map of Sweden

The general map from 1797 was based on geodetic principles (triangulation of the coast line and political boundaries). The visual representation was kept the same as in the earlier generation of maps.

Early cartography - 19th century military mapping

The 19th centrury mapping in Sweden focused on military mapping in the scale 1:100 000.

Each map to be published was hand carved on copper plates, which set the limit for symbolisation and visualisation. The last map made in this way was produced in 1954.

Early cartography - 19th century military mapping

General military map

Original scale 1:100 000

1865 1950

General military map in other scales

Overview map Sundsvall, 1921, 1: 400 000.

Reconesaince map, c 1810, 1: 20 000

20th century cartography - topographic mapping

Three generations of topographic maps (1:50 000)

Edition 3

Edition 1

Edition 2

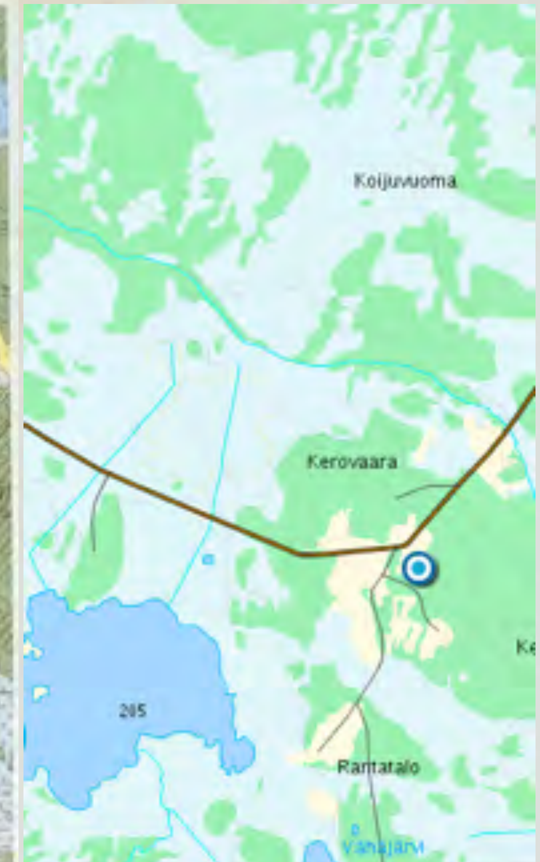
Note how development in printing technique has allowed a change in symbolisation and visualisation.

Topographic and thematic mapping, scale 1:50000

Aerial photo
(Infra red film)

Topographic map

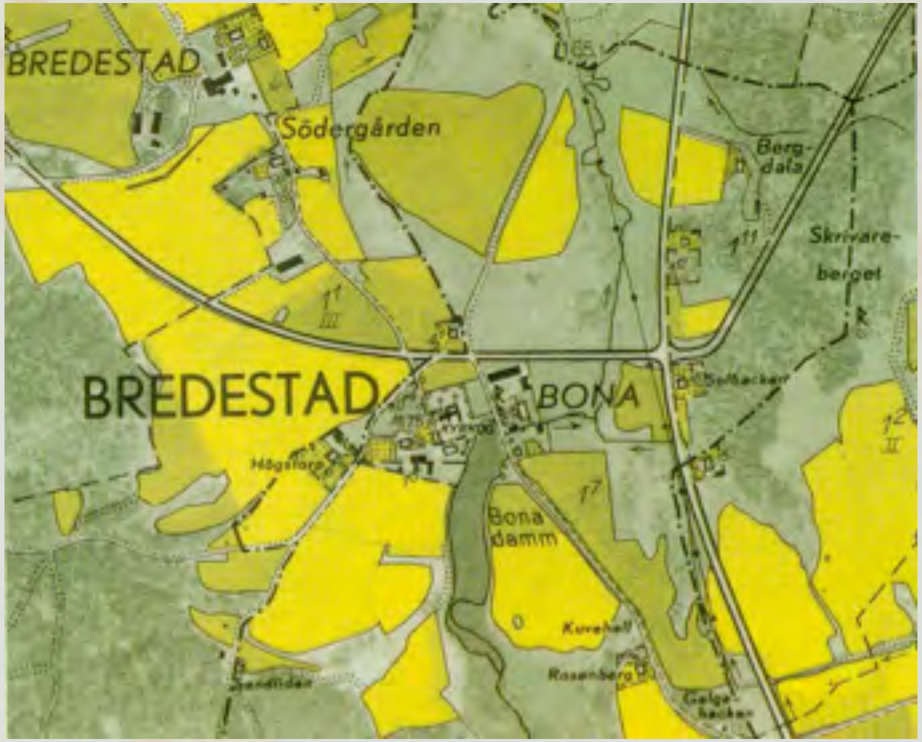
Thematic map
(land cover)



Strongly
generalised map
(www.hitta.se)

Topographic and thematic mapping, scale 1:10000

Older cadaster map, 1: 10 000



Newer cadaster map, 1: 20 000

Development in printing technique has allowed refined visualisation and hence a decrease in map scale while retaining information.

Visualisation at different scales

Aerial photo/
Topgraphic map
in scale 1: 10000

Topographic/
thematic map
1: 100 000

Thematic map
1 : 1 miljon

Scale and generalisation

Visualisation of elevation

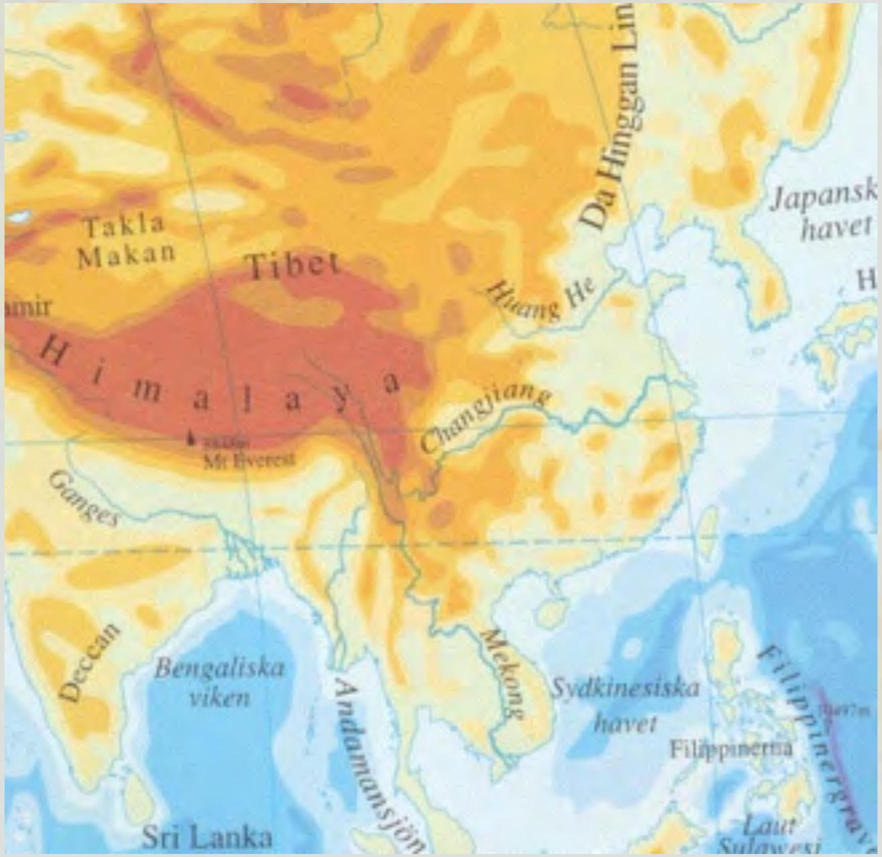
In older maps with less accurate topography line density was commonly used to visualise steepness - general military map over Bohuslän.

Visualisation of elevation

Maps made from orthorectified aerial photos have better geometry, and stereo interpretation of topography can be visualisasied as isolines of elevation (5m).

Visualisation of elevation

In small scale maps topography and bathymetry is sometimes visualised as the main theme (chloropeth map)



Visualisation of elevation

Mountain map with isolines and shadows with light falling from North West. In Sweden the sun never creates these shadows, but the visualisation represents the most common light setting of a study desk.

Visualisation of elevation

Older mountain tourist map with vertical shading

Visualisation and labelling

General military map from 1862 with few names

General military map from 1941 based on further inventories of names.

Topographic/thematic map of detailed infrastructure, but with less labels.

Presentation

Important: application of traditional cartographic rules in the production of these maps and visualisations in order to produce effective maps.

↓

But: GIS software usually does NOT include cartographic rules.
And everyone can make their own maps. **Will they be effective?**

Exploration — Analysis — Presentation

Private visual thinking ⟷ **CONFLICT** ⟷ Public visual communication

Working with own data

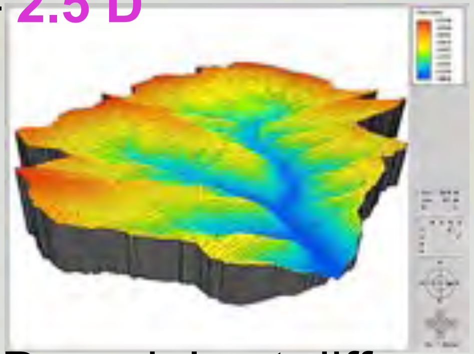
Designing public maps

Visualisation dimensions

1D: data related along a straight line from a point of origin

2D: a map

3D: a physical model of the landscape (cardboard)
a virtual 3D model (rotation, seen from all sides)
a virtual 3D model drawn in perspective – **2.5 D**



4D: adding the temporal dimension (several 3D models at different points in time or an animation)

Geographic Information Systems

Characteristics:

- Geospatial problems are approached and solved in an interdisciplinary way.
- GIS enables integration of data from different sources.
- Data can be manipulated, analysed and visualised.

Data sources:

- surveying
- remote sensing
- statistical data
- physical/chemical measurements
- recycled paper maps

GIS combines geospatial and non-geospatial data from different sources in a geospatial analysis operation in order to **answer questions** about:

Identification →	What is there?
Location →	Where is ... ?
Trend & change detection →	What has changed since ... ?
Optimal path →	What is the best route between ... ?
Patterns →	What is the relationship between ... ?
Models, planning & forecasting →	What if ... ?

Data comparisons

3 basic queries for **single phenomena:**
- Where?
- What?
- When?

Comparisons for multiple phenomena

- Geospatial → Look at different areas at the same scale and compare patterns
- Thematic → Look at the same area on maps for different themes
- Temporal → Look at the same area at different times

Maps in GIS - applications

The role of maps in GIS

Maps in GIS:

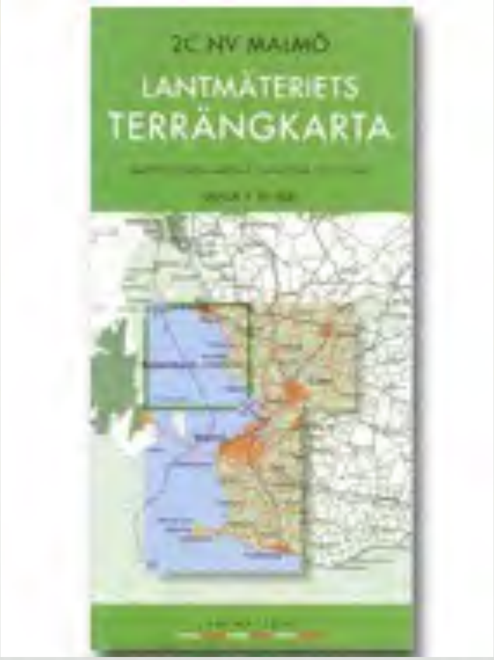
- serve as a graphical user interface between the GIS and the user,
- provide visual indices to geographic phenomena/objects,
- enable exploration of geographic datasets,
- provide means for a visual communication of the results.

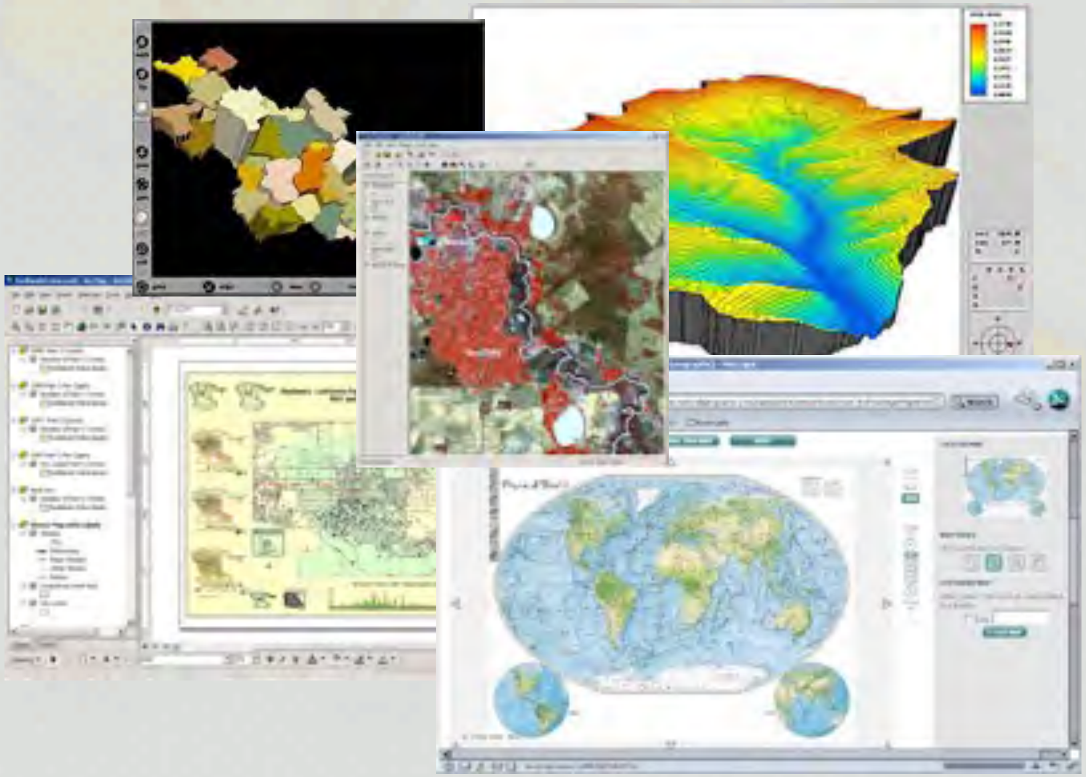
Cartography has a long tradition and experience in combining and integration of datasets from different sources. This experience should be used in a GIS, which is not always the case.

Changing environments

yesterday
There was only one map and only one way to read it.

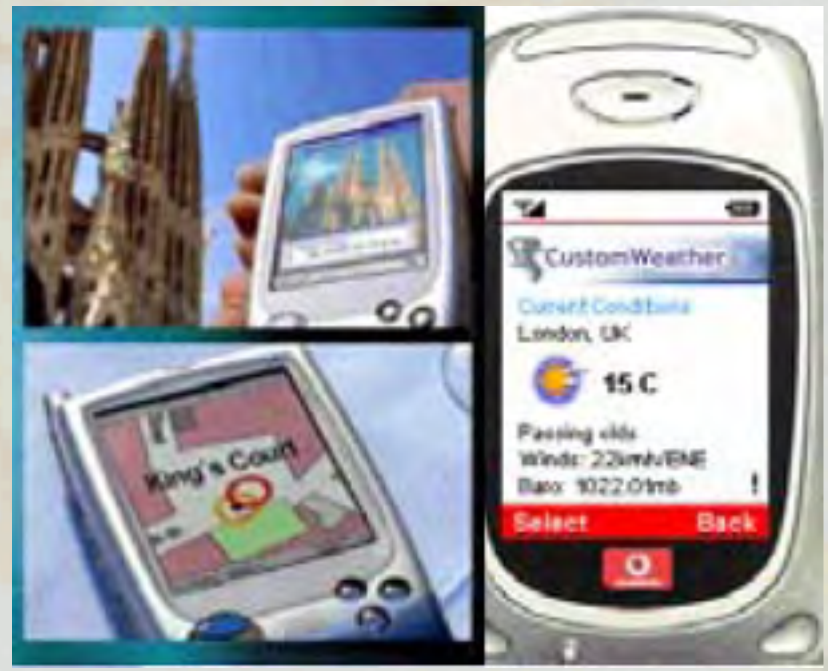
today
There are a thousand ways to create the 'map' and a thousand way to use it.





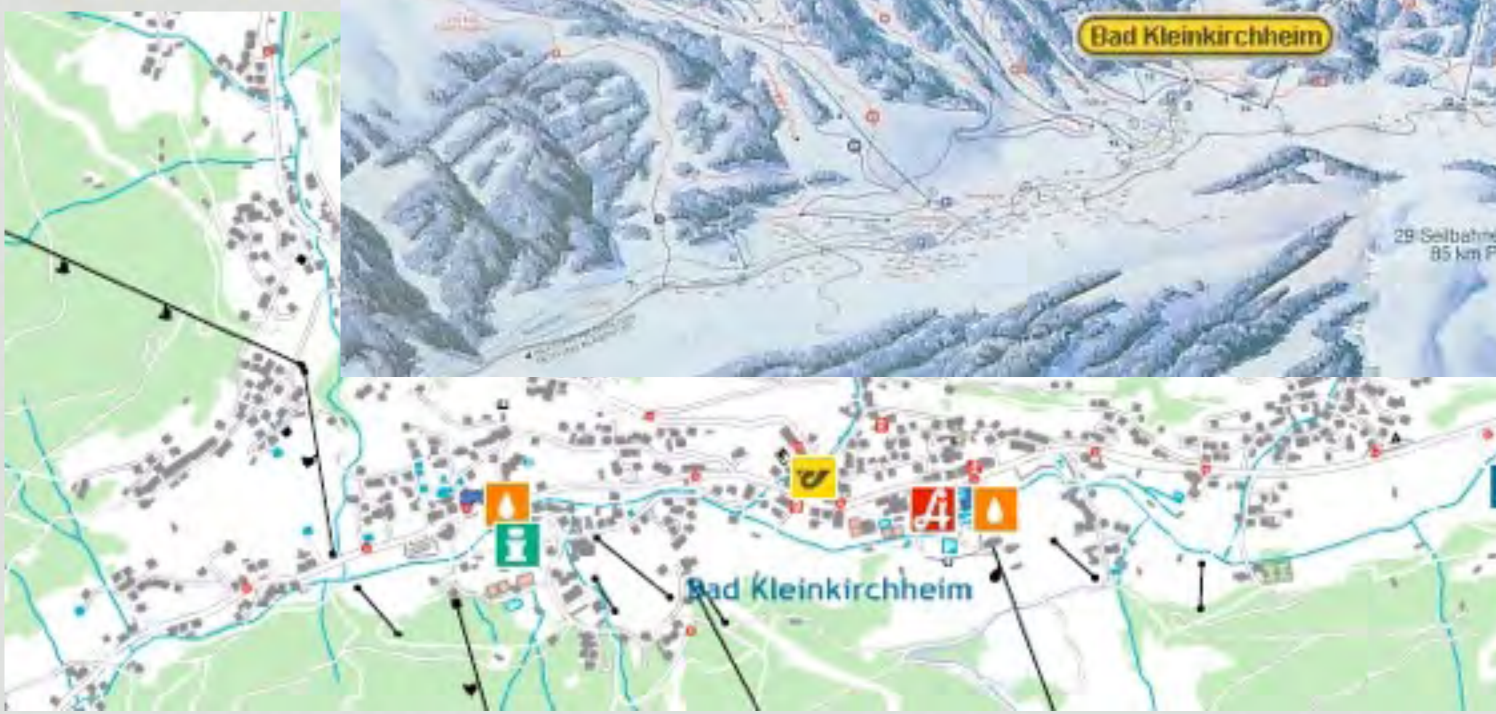
Yesterday – static maps

Today – mobile mapping devices

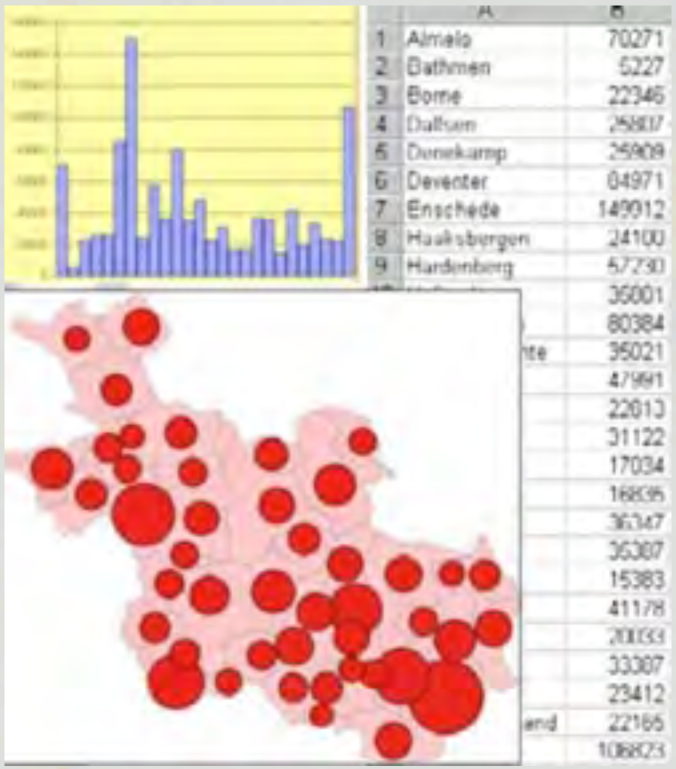


Yesterday – 2D

Today – 3D



Yesterday – traditional

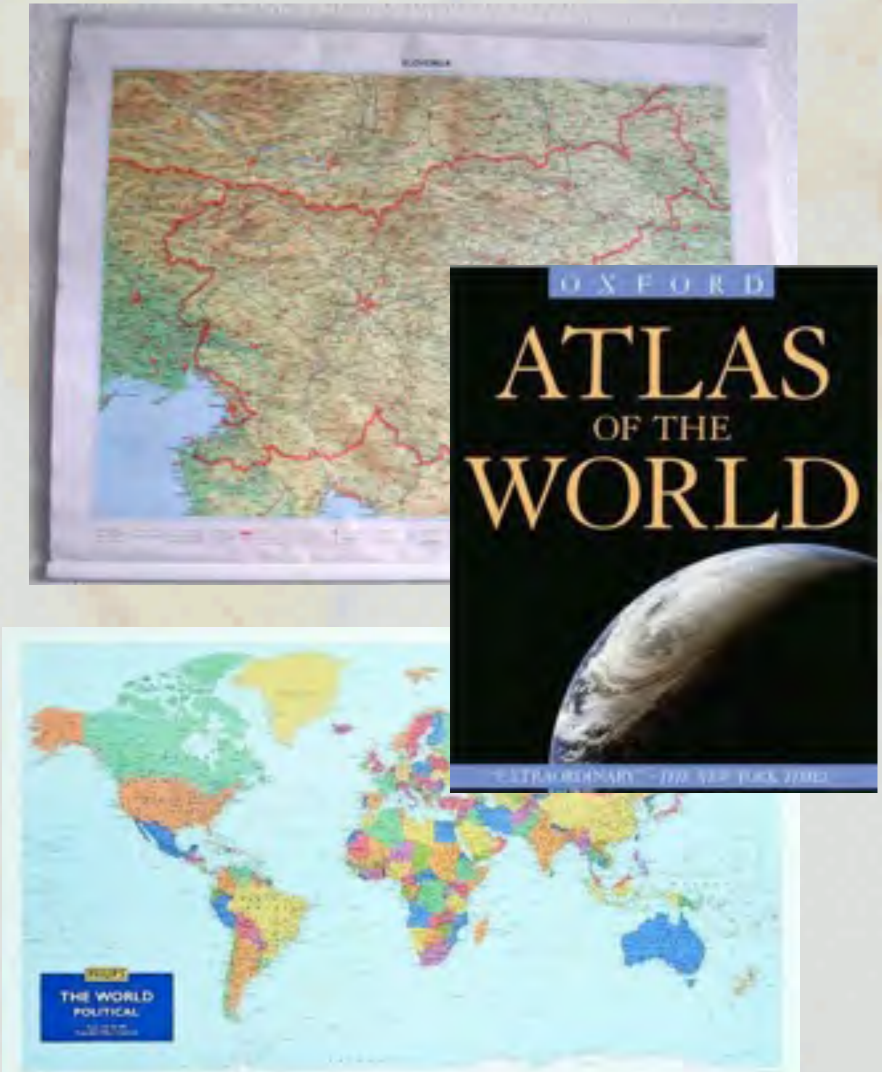


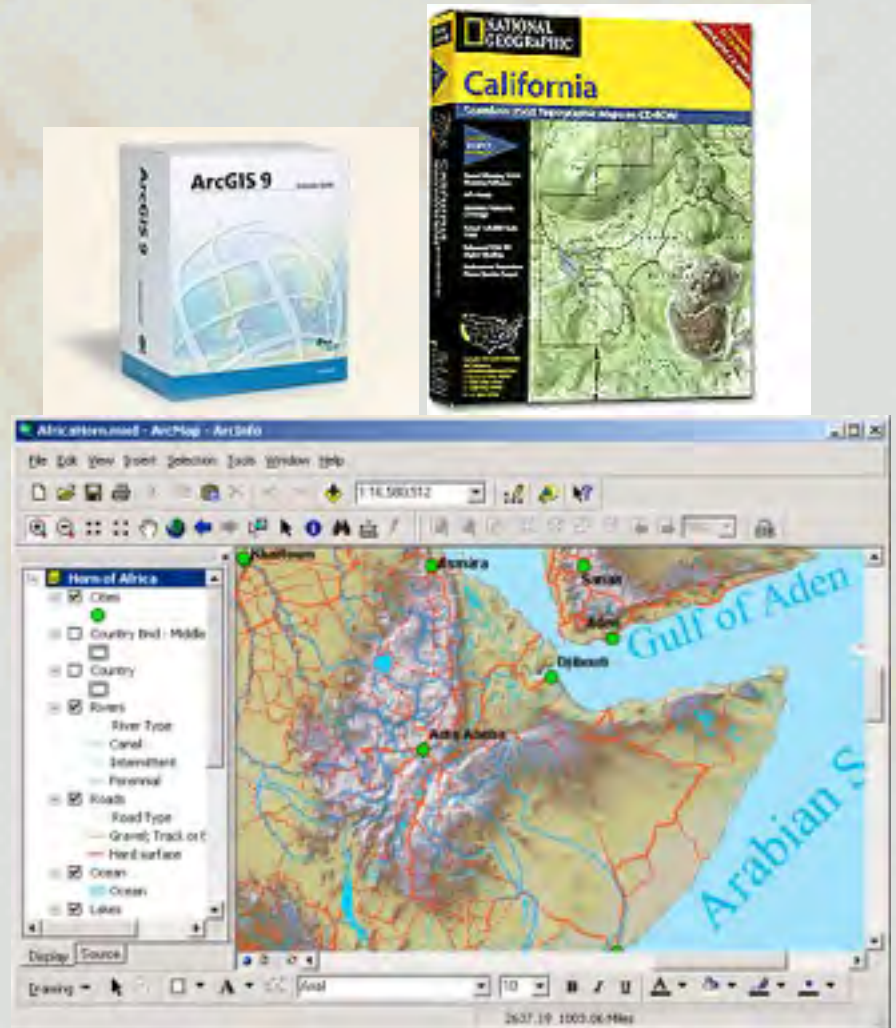
Today – alternative

Yesterday – abstract

Today – real

Yesterday – ready made **Today** – self made





Why geovisualisation?

Users? Who are they, what do they do?

- look for answers/solutions/suggestions…

work on geoproblems

anyone, anywhere, anytime…


STOCKHOLM
INNERSTADEN
Bygger för
Försvarshögskolan och
Utrikespolitiska Institutet
Ulriksdals
Slottsområde

Maps and map types

1. Map functions

- orientation and navigation
- legal use
- town planning
- education
- forecasting
- monitoring

Orientation and navigation

Getting from A to B along a selected route and while travelling, occasionally checking if still on course.

Topographical maps, road maps, sea charts, etc.

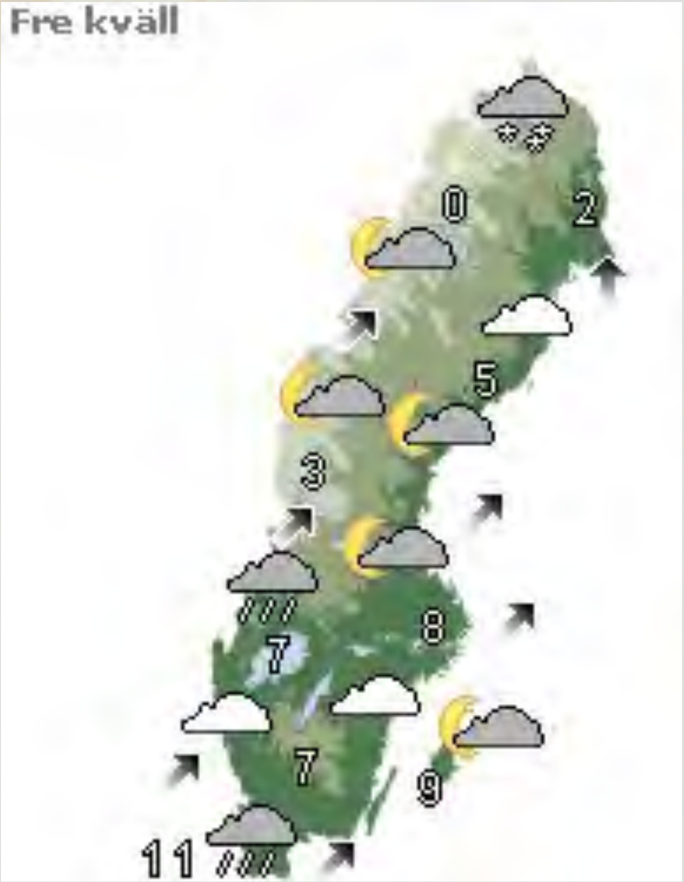
Town planning

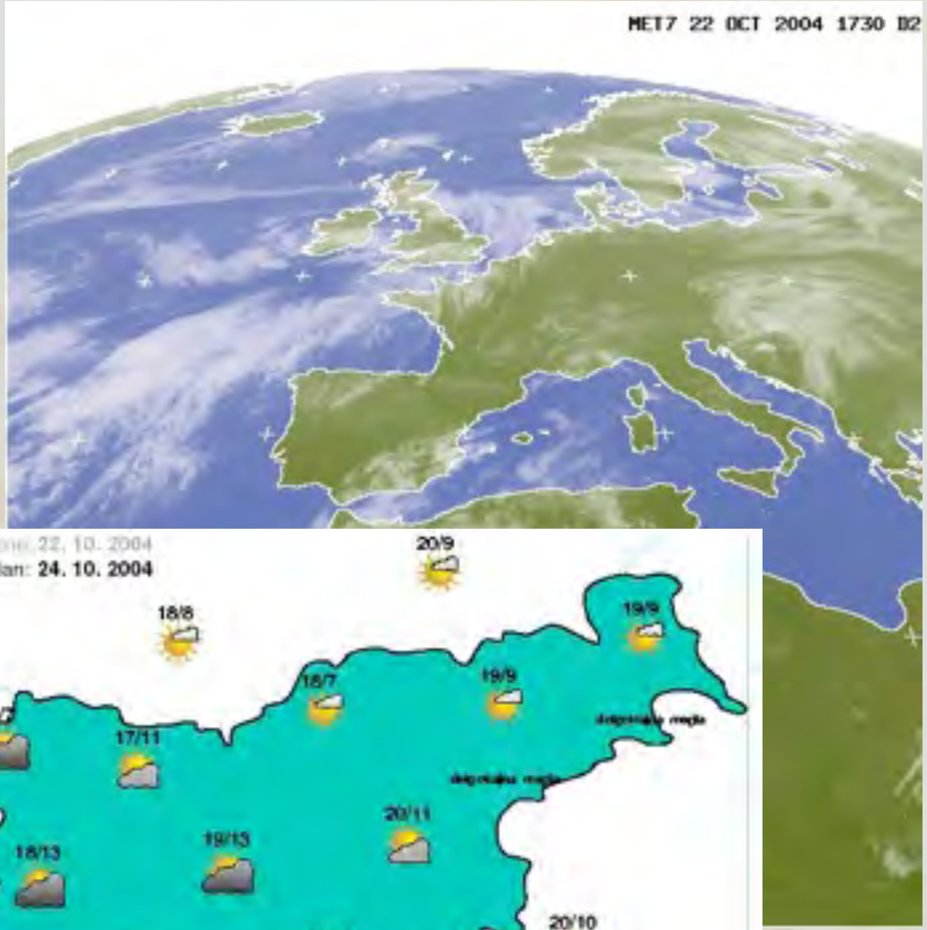
Maps:
- presenting an inventory of current situtation,
- defining development processes and
- contain propositions for future situations.

Forecasting

Extrapolating from the past phenomena to the future.

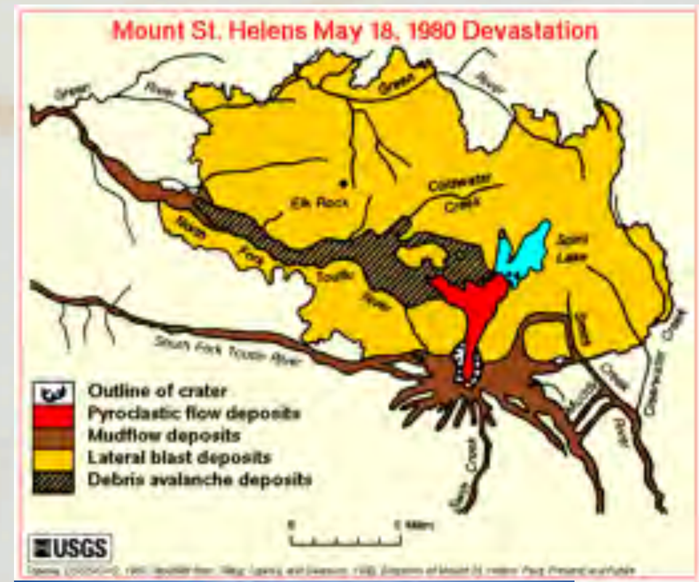
Weather, spread of diseases, etc.





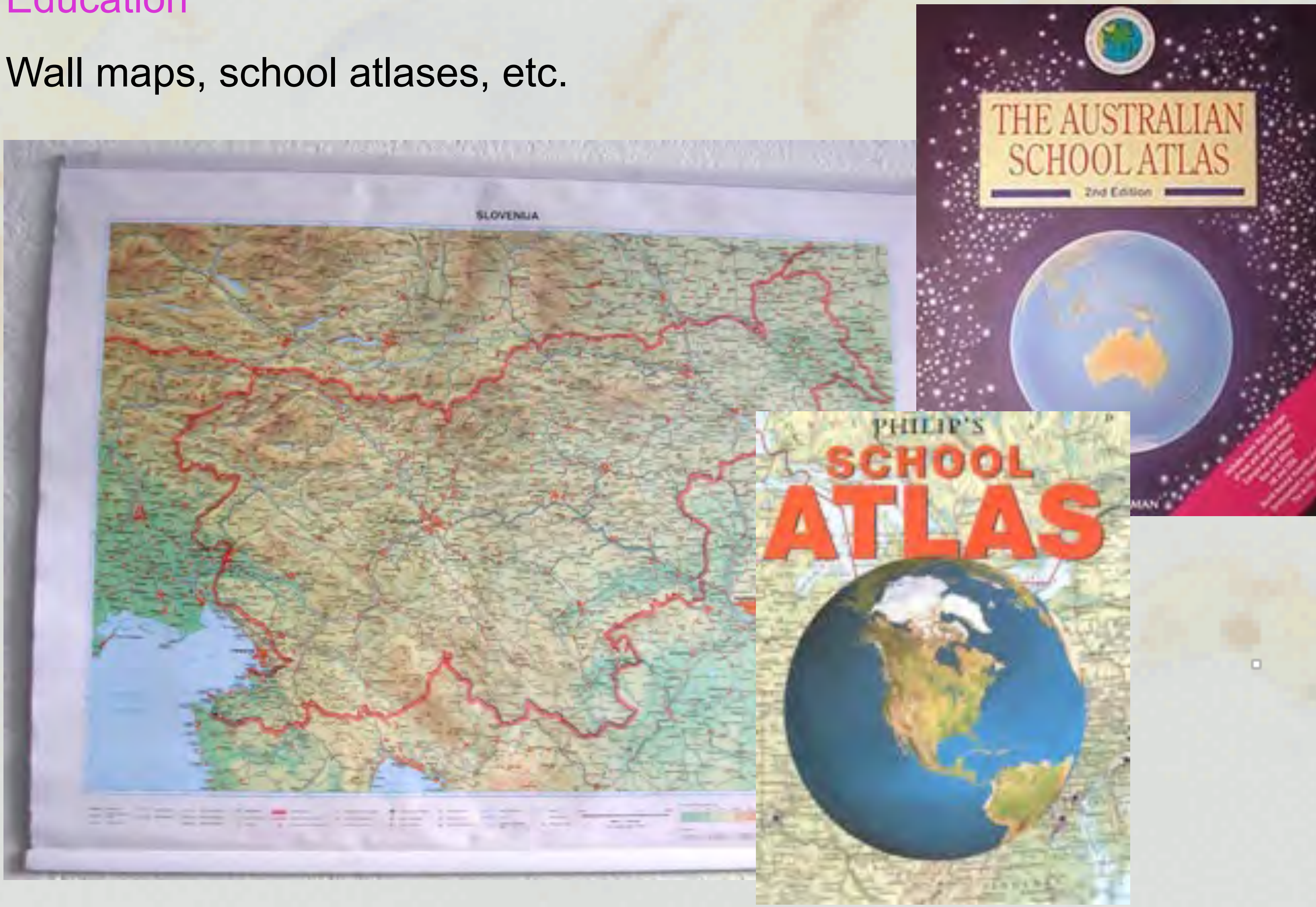
Monitoring

Disaster management: floods, earthquakes, volcanoes, forest fires, hurricanes, etc



Education

Wall maps, school atlases, etc.



Legal use

Cadastral maps

2. Map types

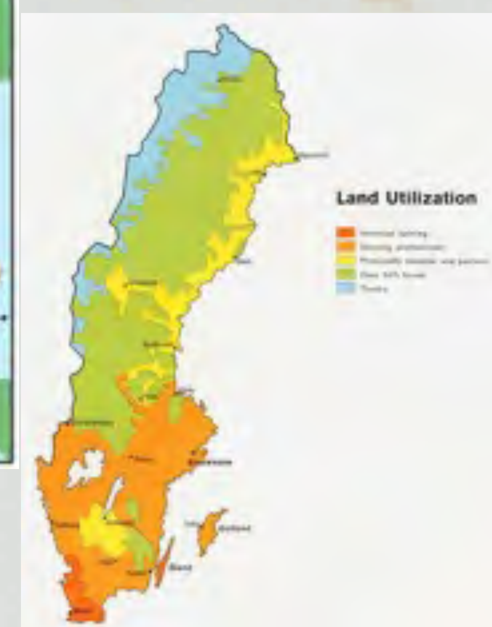
Topographic maps

General image of the Earth's surface

Traditional division of map types

Base for

Thematic maps



Distribution of one particular phenomenon

Traditional division less relevant in digital environments, because both map types (topographic and thematic) consist of several layers.

Topographic map = Terrain +
Roads +
Railways +
Settlement +
Hydrography +
Geographical names +
Land cover +
Country/county boundaries

} **Layers**

Each of these layers is **a thematic map** in itself.

3. Visualising topography

Mapping the terrain

A relief display is a geometrically accurate view of the terrain and its shapes (morphology).

3D →

The choice of the terrain mapping method depends on the **purpose of the map**:
- do we want to represent terrain globally (as in a tourist map or a skiing map) or
- do we need to be able to determine the heights to 10cm accuracy (when planning a large site, a dam, for example)?

Height

- Absolute – numerical values at contour lines or height points
- Relative – is a certain location higher/equal/lower than other locations?


Layer tints – relative height
Absolute height
Arnoldstein
Podklošter
Finkenstein
Korensko sedlo
Tarvisio
Trbiž
Kranjska Gora
Mojstrana
Mangart
2679
Predel
Jalovec
2645
Log pod Mangartom
Bavški Grintavec
2347
Triglav
2864
Škrlatica
2740
Razor
2601
Kanjavec
Trenta
Visoki Kanin
Rombon
2208
Bovec
Kal-Koritnica
Soča
Čezsoča
JESENICE
BLED
Lesce
Bohinjska Bistrica
Stara Fužina
Kobarid
Matajur
Tolmin
Drežnica
Podbrdo
Plaski Vogel
Krn
V. Bogatin
Stol
Camporosso
Ugovizza
Fusine
Rateče
Podkoren
Gozd Martuljek
Dovje
Vršič
Montaž
Viš
Cave del Predil
Krasji Vrh

Three common methods of relief display

→ Hill shading – display the shades on the slopes, produced by a ficticious light source.

→ Contour lines – draw isohypses (contour lines), the lines that connect the points with the same elevation.

→ Layer tints – assign a cetrain colour to layers between two contour lines (green = low relief, red-brownish = high relief).

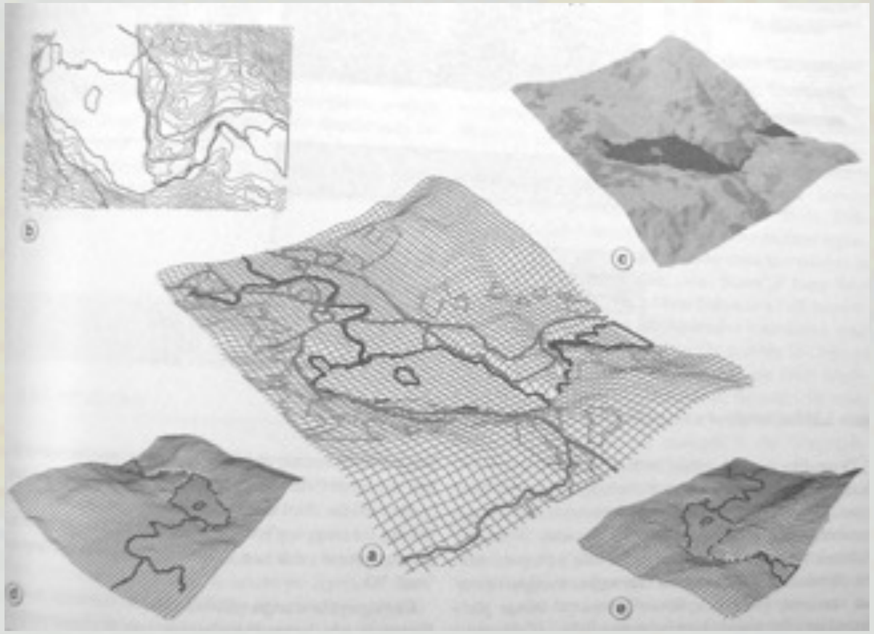

Alesjaurestugorna
1991
Vealevárri
Bergf
Mearhama-čohkka
Lulip Vealevárri
Áziz
Visttasčohkka
Tjäktjastugan
1935
Bossus-čohkka
1938
Roahp
1288
Juovva-čorru
1209
Rásse-bákti
Duopmačohkka
Visttasvággi
Sealgga Sálka
Hukejaure stugan
Kebnekaise
Giebnegáisi
1536
Gahkasčohkka
2111
Tarfala
Gáidumčohkka
Ruška
1708
Kebnekaise fjällstation
Nikkaluokta
Pirttivuopio
Buollanorda
Árosjokk
Sitasjaurestugorna
1342
Singistugorna
1759
Skárttoaivi
Paittasjärvi
Lauk
1544
Sluer Jierta
Passglaciären
Urtti čohkka
1464
1013
Bierjasčoh
Kaitumjaurestugorna
933
Áilladis
Guorbavárdu
1810
Kallaktjåkkå
Kungsleden
Čuonjalahku
Tjuonjalako
Čoavrrik
Tjåurek
1704
Gorsačohkka
Kårsatjåkka
Deavnnačohkka
Taunatjåkka
1055
423-453
Stora Sjöfallets nationalpark
1731
Guobirčohkka
Tjuonajakk
Vakkotavare
Stora Sjöfallet
Hill shading


Jättesås
Högalid
Öknen
Jättesåsm.
Maderna
Tuvem.
45,74
Ödegårdshagen
Bohusleden
67
Vassbo
Ryra
Vassbosjön
43,5
Backen
Barrlindekasen
Bjälledal
Klåppevattnet
Sjöhagen
66
Pölemaden
Funneshult
Tegen
125
113,78
Torpet
Bukullen
174,71
Björkebacken
Sågen
Krokevattnet
Buvattnet
Aspekärr
Åsen
L. Galten
Hälleröd
Ulvehed


Layer tints
Arnoldstein
Podklošter
Korensko sedlo
Finkenstein
Tarvisio
Trbiž
Kranjska Gora
Mojstrana
JESENICE
Mangart
2679
Jalovec
2645
Predel
Log pod Mangartom
Bavški Grintavec
Triglav
2864
Trenta
Bovec
Visoki Kanin
2587
Rombon
2208
Kanjavec
Plaski Vogel
Krasji vrh
1772
Krn
V. Bogatin
Kobarid
Matajur
Tolmin
Vogel
Rodica
Črna prst
Podbrdo
Bohinjska Bistrica
Stara Fužina
BLED
Lesce
Škrlatica
2740
Razor
2601
Tosc
2275
Kepa
Golica
Camporosso
Žabnice
Ugovizza
Ukve
Malborghetto
Naborjet
Cave del Predil
Rabelj
Dve Špici
2047
Montaž
2753
Viš
2666
Kal-Koritnica
Soča
Čezsoča
Žaga
Stol
1673
Trnovo ob Soči
Borjana
Idrsko
Ladra
Drežnica
Kamno
Volarje
Tolminske Ravne
Fürnitz
Brnca
Rosenbach
Podrožca
Rateče
Podkoren
Fusine
Bela Peč
Gozd Martuljek
Dovje
Vršič
1611
Srednja vas
Koprivnik
Bohinjska Bela
Blejska Dobrava
Spodnja Gorje
Zali Log
Ratitovec
Altemaver
1678
Sorica
BELJAK
(501)
Nötsch
Čajna
Feistritz
Bistrica
Poludnik
Ojstrnik
2052
Vorderberg
Blače
Faak am See
Bače
Rosegg
Rožek
St. Jakob
Maria Elend
Podgorje
Kluže
Breginj
Logje
Robič
Livek
Srpenica
Kneške Ravne
Hudajužna
Porezen
Montesanto di Lussari
Višarje
Valbruna
Ovčja vas
1766

Other methods of relief display

Hachuring

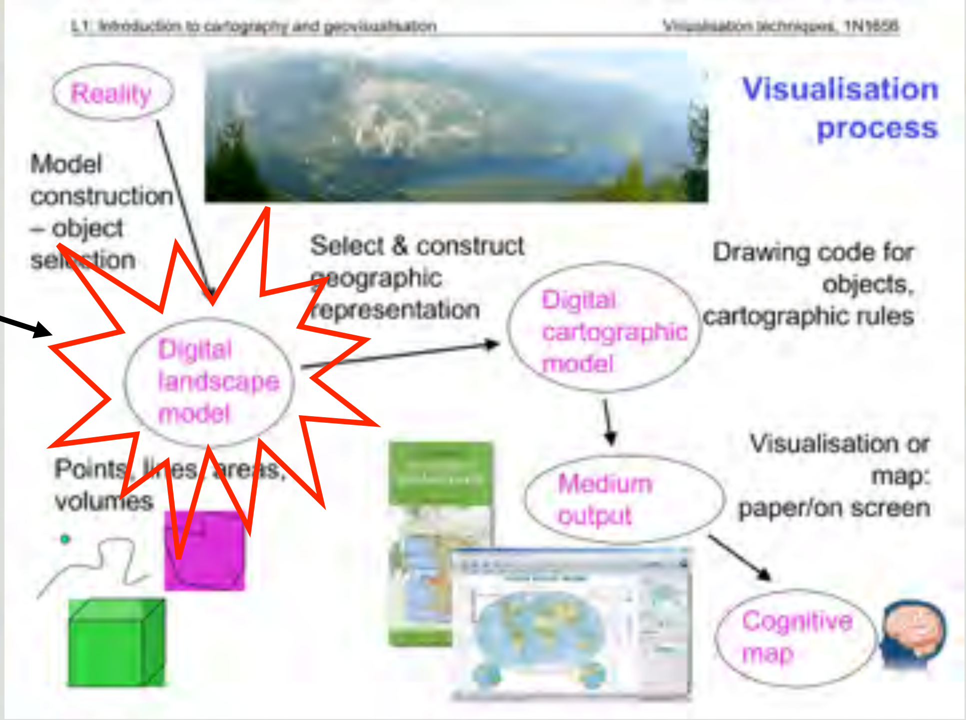


Perspective views

A relief display in a computer – **a digital terrain model, a DTM**: a digital 3-dimensional representation of the terrain surface and selected 0-, 1-, 2- and 3-dimensional objects that are related to the surface.

If only elevation is represented, we get **a digital elevation model, a DEM**.

Both are digital landscape models.



Collecting data for a DTM/DEM

- Digitising contour lines from existing maps
- Surveying techniques
- Photogrammetric techniques from aerial and satellite data (optical&radar)

Model quality depends on:
- density of sampling points (spatial resolution),
- interpolation method (estimating the elevation between the sampling points).

Applications of DTM/DEM – surface analysis

A slope map – shows the maximum rate of change of elevation.

Aspect – the orienation of the slope.

Hydrological maps

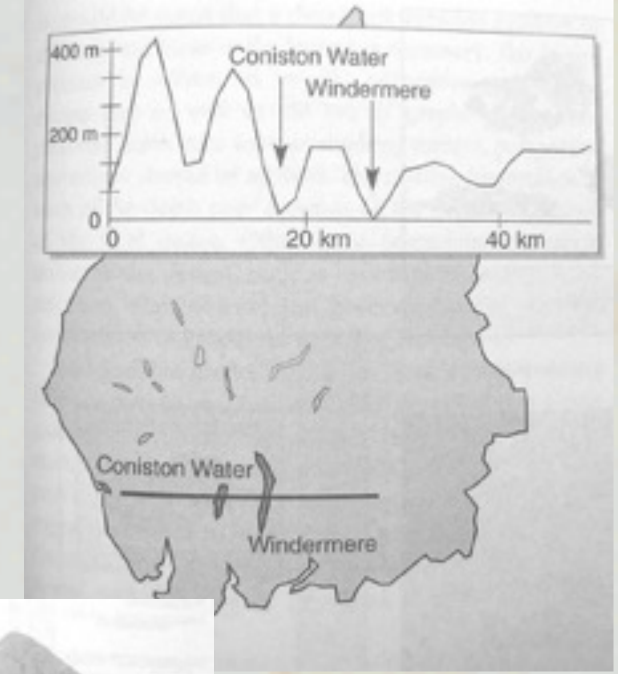
A flow direction map – into which direction the water would flow from each sampling point/raster cell.

A flow accumulation map – which neighbour points/cells drain into a particular point/cell.

A drainage network – a network map of the runoff on the terrain, where the water will flow on the surface.

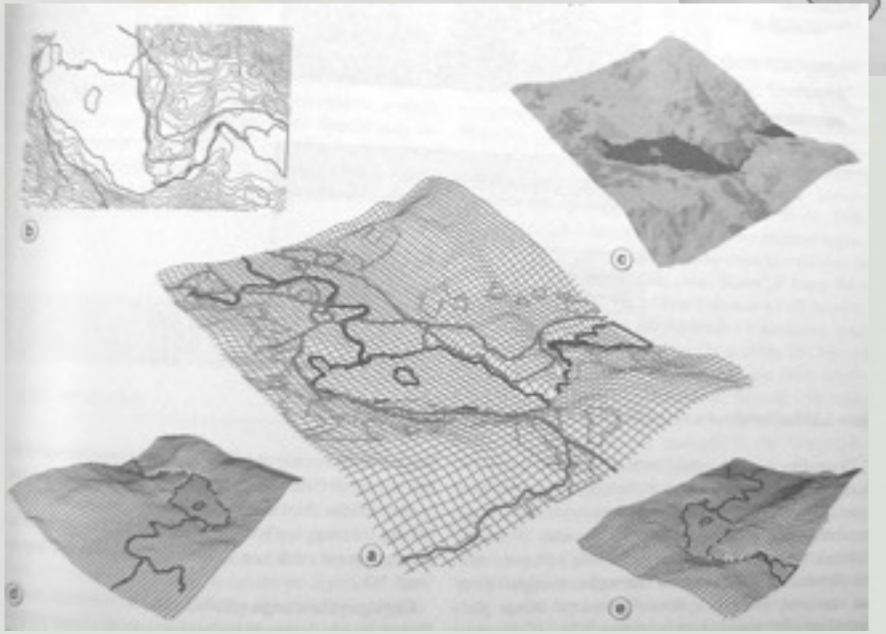
Terrain visualisations from DTM/DEM

Profiles

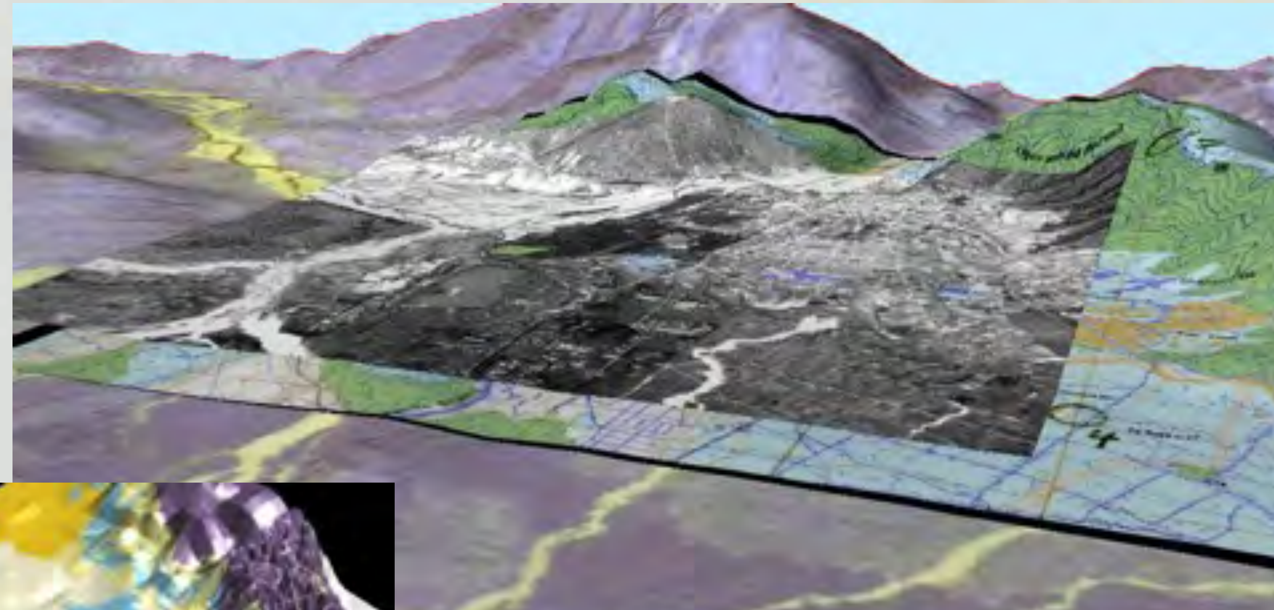


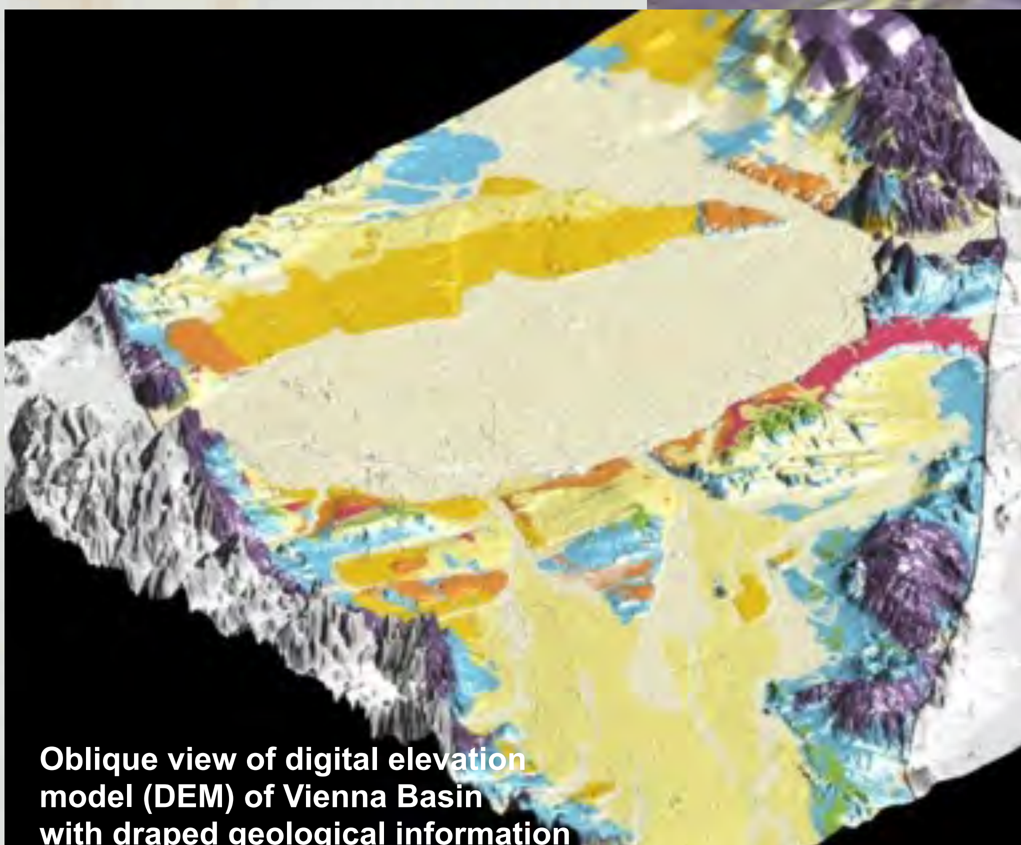
Shaded relief maps

Perspective maps



Terrain visualisations from DTM/DEM – drapping a satellite image or a thematic map over a 3D visualisation of the terrain





Oblique view of digital elevation model (DEM) of Vienna Basin with draped geological information