Ekonomická fakulta
Faculty of Economics
Jihočeská univerzita v Českých Budějovicích
University of South Bohemia in České Budějovice

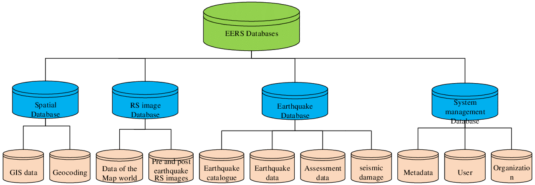
Geographic Information Systems 1
Lecture 7: Data sources for GIS

Renata Klufová
University of South Bohemia, Faculty of Economics

April 2021

In the framework of building **GIS application**, we address the following main tasks:

- design the data structure - by analysing the situation, arrive at the ideal coverage of the problem by map layers,
- acquire data - decide on a suitable data source for our application.



The most challenging problem in GIS is always to build the **geodatabase**, i.e. to acquire the necessary geographic data in the form of maps, databases, statistics, etc. It has been reported that more than 70% of the cost of creating an application is spent on acquiring the data.
50 - 80% of the data processed by the public administration or decisions taken by it is of spatial nature.

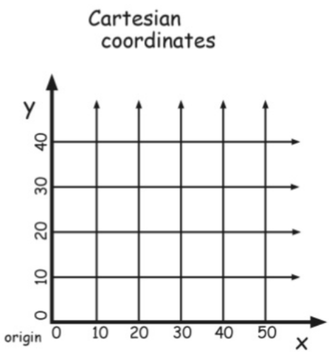
Spatial data (geodata) ... there are a number of definitions - for example:

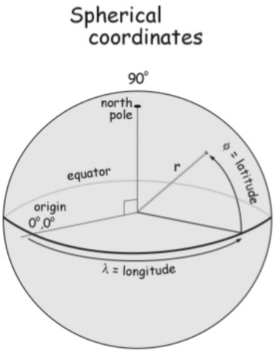
- McDonnel a Kemp (1995): *Spatial data is any data that contains a formal positional reference, e.g. a reference to a grid cell. These are e.g. DPZ or map data.*

- Rapant (2006): *Spatial data is data that relates to specific locations in space and for which the locations of those locations are known at the required level of resolution.*

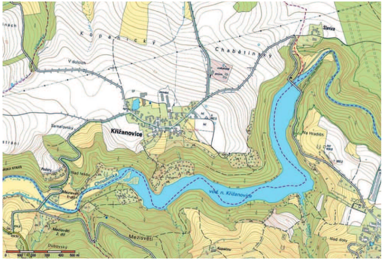
The datum that binds the data to a specific location in space is called **spatial reference** (georeference):

- coordinates (in space, on a map),
- address,
- plot number, etc.





- **basic** (in a broad sense) - necessary for most GIT applications:
  - **reference geodata** - used for spatial georeferencing of own geodata (common basis for referencing thematic goedata) - e.g. ZABAGED, DMU 25,
  - **geodata of common basis** - a set of geodata necessary for optimal use of most GIT applications, i.e. geodata that represent a sufficient (spatial) reference for most spatially referenced data;
- **application dependent** - application specific = **topic data**.



= **Basic geographic data base** (ZABAGED - ČÚZK) - digital geographic model of the territory of the Czech Republic at a scale of 1:10 000 (ZM 10) - free for public administration - a total of 123 types of objects divided into classes (dgn, shp, gml formats):

- settlements,
- economic and cultural objects,
- communications,
- distribution networks and pipelines,
- hydrography,
- territorial units,
- vegetation,
- terrain relief,
- geodetic points.

history:

- originally ZABAGED 1 (vector) and ZABAGED 2 (raster),
- 1995 - initial fulfillment of ZABAGED© by vector digitization of ZM 10 print documents,
- 2001 - digitalisation completed,
- since 2006 - new technology of updating (three-year cycles for 1/3 of the territory of the Czech Republic) and management (central database, on-line updating).

= digital model of the area - vector database at a scale of 1:25 000 (VGHÚŘ Dobruška) - layers:

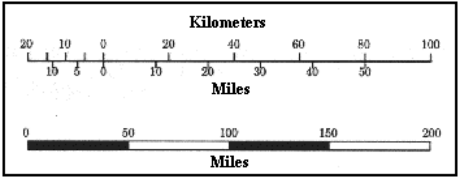
- hydrology,
- communication,
- pipeline, telecommunications and energy routes,
- vegetation cover,
- settlements,
- industrial and other buildings,
- borders and fences,
- altimetry.

for viewing:

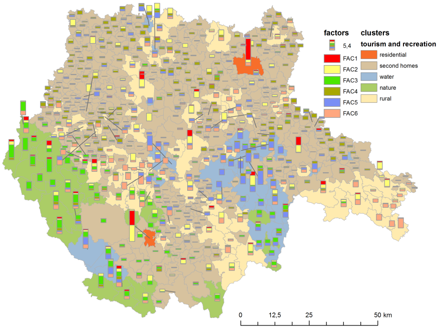
DMÚ 25

Scale (or **spatial resolution**) depends on the level of use of the reference geodata:

geographic level	spatial resolution	scale level	range
European	> 100 m	small scales	$<$ 1:250 000
national	~ 25 m	middle scales	1:100 000 - 1:250 000
regional	~ 10 m	middle scales	1:25 000 - 1:50 000
local	$< 2{,}5$ m	large scales	$>$ 1:25 000



... cover all other areas of geodata that can be used in individual applications: socio-economic data, natural resource data, possibly special-purpose versions of basic data (e.g. road centrelines for vehicle navigation) - mostly **topical data**



Depending on the nature of the input data, we divide the sources into:

1. **Primary** - all forms of field measurement - can be very laborious and time consuming;
2. **Secondary** - all forms of data retrieval from already finished geodatabases that were originally created for other purposes (they were once primary) - disadvantage: likely deviation from our specific intent.

Primary sources include all measurements made by the direct presence of the surveyor at the location in the form of direct contact of the measuring device with the phenomenon under study (various forms of geodetic measurements) or by some variant of non-contact imaging - from a distance (DPZ).

Remote Sensing - exploration of reality from a distance - forms:

- **Aerial Imaging** - taking photographs of the terrain surface from a relatively low flying aircraft - e.g. Geodis.
- **Scanning objects from the Earth's surface** - for example, laser scanning of a 3D object (buildings).
- **Multi-spectral imaging** of the Earth from a great distance using space satellites (in polar orbits or geostationary orbits) or, for example, weather balloons in the uppermost layers of the atmosphere.

Photographing the Earth from a distance is related to other disciplines associated with the processing of photography - **photogrammetry** and **photointerpretation**.

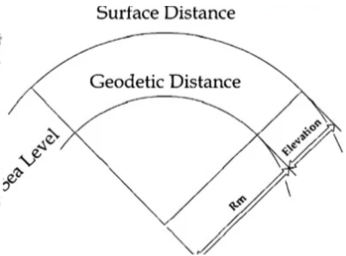
... the most accurate and reliable way of obtaining (geometric) information about the site under study.

For surveying, we usually use some form of surveyor's notebook in which we record the data:

- The geographic location of the measuring member (can be part of a notebook) - typically global positioning (some form of GPS). GPS systems are still very much evolving and achieving ever higher positioning accuracy.
- The value of the investigated phenomenon obtained by the measuring member.
- The time and other circumstances of the measurement, such as important influences affecting the measurement.

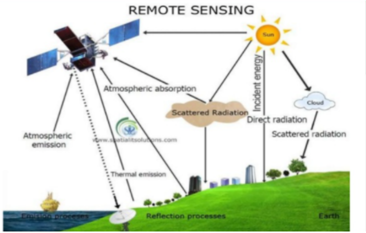
postprocessing - editing of data from the notebook and their inclusion in the geodatabase

Primary sources of data
geodetic surveying



Geodetic measurements are used **when creating large-scale maps** (cadastral maps, technical maps, plans, etc.), as it produces vector data with accuracy in units of cm.

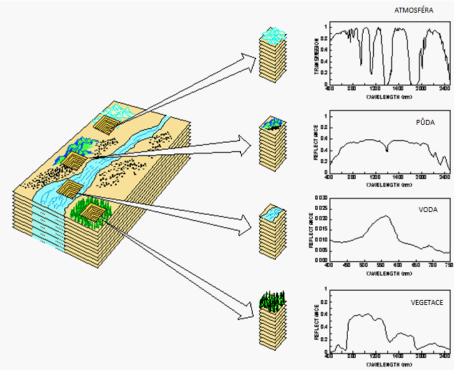
RS = method of obtaining information about objects on the Earth's surface without direct contact with it: data acquisition, data processing, analysis → resulting visualization and image interpretation

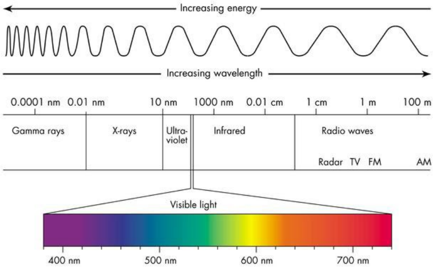


basic principle of RS: measurement of the amount of electromagnetic radiation reflected or emitted by the Earth's surface - the source of the radiation is any object on the Earth's surface whose temperature is greater than absolute zero (i.e. -273.15^oC)

is measured:

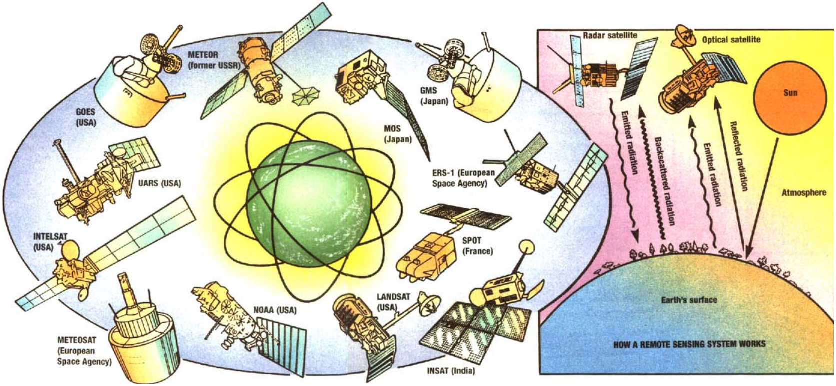
- the radiation emitted by the Earth's surface itself,
- solar radiation reflected by the surface,
- or radiation emitted by an artificial source (e.g. radar) that is reflected by the Earth's surface.





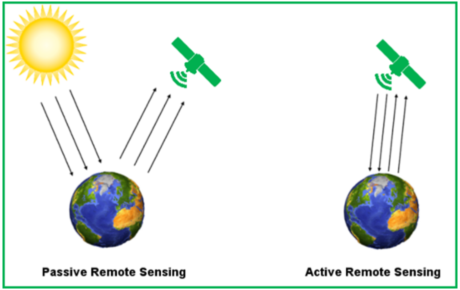
The Earth's surface and the objects on it have certain physical properties; when electromagnetic radiation strikes that surface, the radiation interacts with the particular surface it strikes.
The reflected radiation then gives us information about the surface it bounced off. Based on the radiation reflected by the Earth's surface, we are able to determine what substance it is.

Theory	Praxis
1666 - Newton - decomposition of white light into the colours of the spectrum	1839 - Niepce, Daguerre - discovery of photography
1880 - Herschel - discovery of infrared radiation	1858 - Nadar - photography from a balloon (Paris)
1873 - Maxwell - theory of electromagnetic radiation	World War I - photos from airplanes
	WWII - radar, color IR photo
	1960 - TIROS-1 - 1. meteorological satellite
	1972 - ERTS-1 (Landsat 1)
	1990s - NASA - hyperspectral sensors

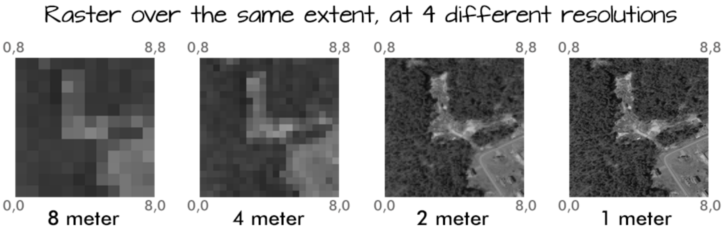

METEOR
(former USSR)
GOES
(USA)
GMS
(Japan)
MOS
(Japan)
UARS (USA)
ERS-1 (European
Space Agency)
INTELSAT
(USA)
SPOT
(France)
LANDSAT
(USA)
NOAA (USA)
METEOSAT
(European
Space Agency)
INSAT (India)
Radar satellite
Optical satellite
Sun
Emitted radiation
Backscattered radiation
Emitted radiation
Reflected radiation
Atmosphere
Earth's surface
HOW A REMOTE SENSING SYSTEM WORKS

RS systems use two types of sensors for sensing:

- **passive** - records radiated or reflected electromagnetic waves,
- **active** - uses its own source of electromagnetic waves, so it can be used both day and night - advantage: ability to monitor much longer wavelengths - ability to better penetrate the atmosphere, clouds and even shallow water, disadvantage: need to provide power to the sensor.

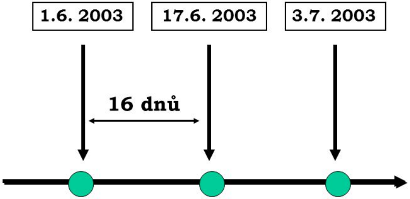


- **spatial resolution** - defines how much area on the Earth's surface corresponds to one pixel in the image;
- **spatial resolution** - defines how much area on the Earth's surface corresponds to one pixel in the image;
- **spectral resolution** - the width of the electromagnetic spectrum that the radiometer is able to sense, but also the number of bands into which this interval is divided



Časové rozlišení

Frekvence s jakou systém vytváří snímky stejného území:



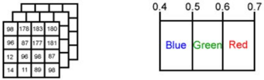
Časové rozlišení snímků z LANDSATu

Spektrální rozlišení

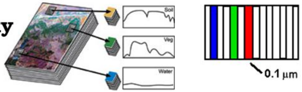
- **Počet vytvářených snímků v MS režimu**
- **Šířka intervalu zaznamenaných vlnových délek**

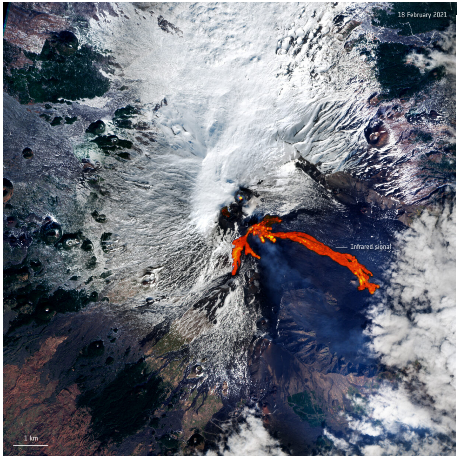
panchromatický snímek

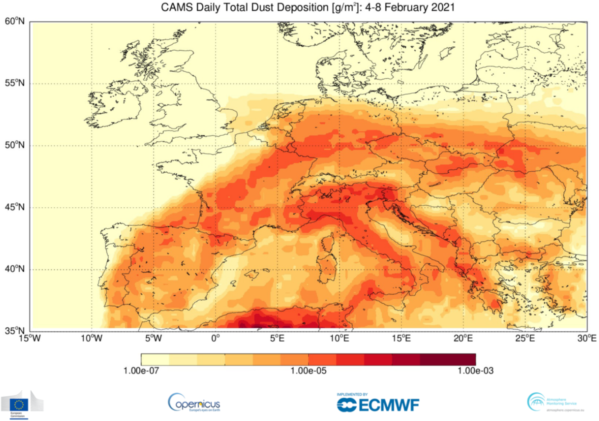
multispektrální snímky



hyperspektrální snímky



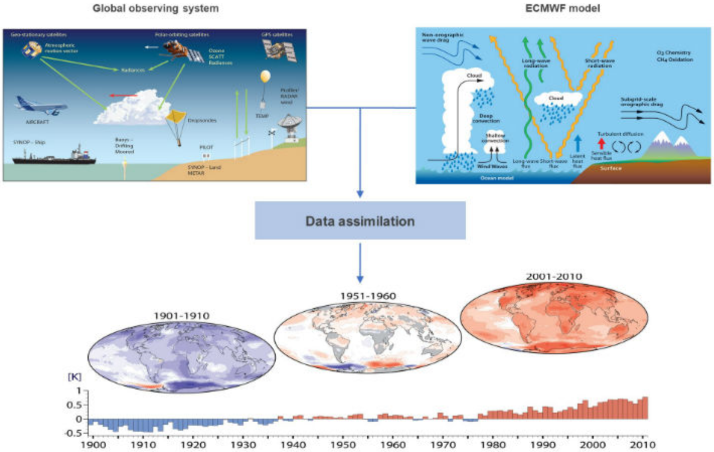




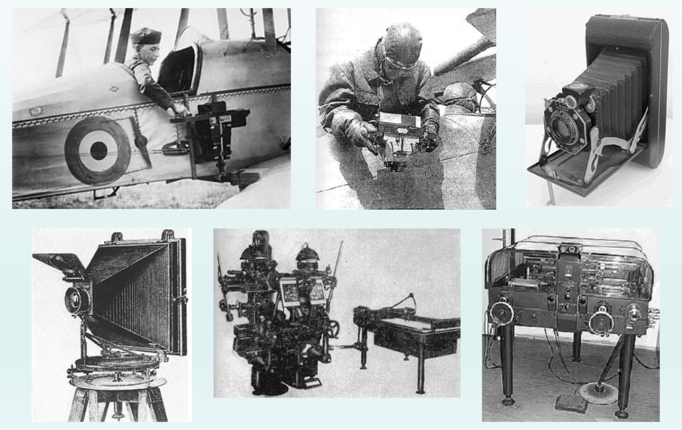
Etna - eruption 16 18 February 2021

orange snow - early February 2021

- stained with dust from the Sahara


Global observing system
ECMWF model
Data assimilation
1901-1910
1951-1960
2001-2010
[K]
1
0.5
0
-0.5
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

Photogrammetry is concerned with reconstructing shapes, measuring dimensions and determining the position of objects that appear on photographic images.
... part of RS



According to the number of evaluation images we divide photogrammetry into:

- **single image** - only planar coordinates can be measured on separate frames. In aerial photogrammetry, the positional component of a flat area can be acquired in this way from both vertical and oblique images.
- **two image** - the spatial coordinates of the object can be evaluated from a pair of frames. The measurement object must be displayed simultaneously in both images. If stereoscopic perception is used to evaluate the images, we speak of **stereophotogrammetry**.

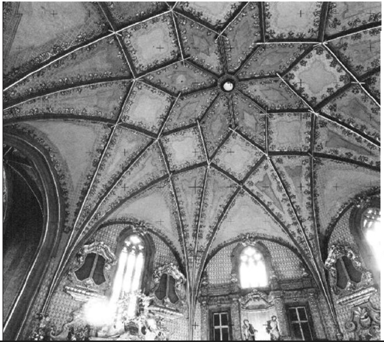
According to the method of image processing (so-called conversion of image coordinates to planar or spatial coordinates):

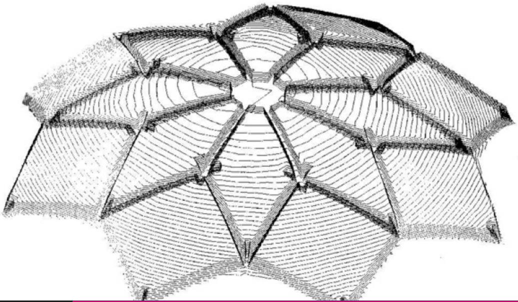
- **analog** - the evaluation requires an optical-mechanical device operated by a specially trained operator with long-term training;
- **analytical** - converts image coordinates to geodetic coordinates using spatial transformations that are solved on computers;
- **digital** - uses a digital image as input - a scanned conventional image or an image taken directly by a digital camera.

- Information about objects is not obtained by direct measurement, but by measuring their photographic images.
- The image is an exact central projection of the object (the image of each point, line and plane is in turn a point, a line and a plane, the line of the object and the image point passing through the centre of the projection).
- The basic task of photogrammetry is to convert this central projection into a rectangular projection.

We distinguish photogrammetry:

- **aerial** - next slide,
- **ground** - best suited for use in rugged terrain - mapping in high mountain terrain, determination of cubatures in surface mines, measuring movements of bridges and dam bodies, construction - documenting facades, vaults, etc.;
- **close** - documenting crime scenes or traffic accidents.





Aerial photogrammetry = geodetic method - the geometric shape of a part of the Earth's surface is not determined in the field, but on its image taken from the air:

- images usually have better spatial resolution than satellite images,
- more operational operation - the aircraft can be directed more quickly over the sensed area,
- disadvantage: higher spatial distortion and more expensive image acquisition than satellite,
- used mainly for the creation of orthophotomaps,
- often also for taking hyperspectral data - geology, vegetation studies,
- suitable for documenting rapidly changing events - floods, storms, fires, etc.

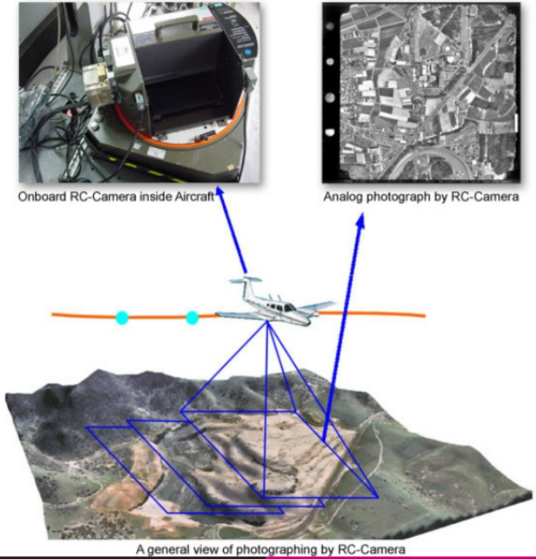
Depending on the shooting direction (the direction of the axis of the shot), we can distinguish between images:

- horizontal,
- vertical,
- oblique.

Depending on the shooting method:

- individual (indicative),
- serial - photographed consecutively so that they overlap.

The longitudinal overlap of images in rows should be 60%, the overlap of rows 30%. Then we can be sure that each location in the field has been photographed twice. Vertical images are the most preferred and most used, where there is a uniform scale over the entire image area.


Onboard RC-Camera inside Aircraft
Analog photograph by RC-Camera
A general view of photographing by RC-Camera

Secondary sources are provided by a bank of existing map works. We assume that by reusing them we will save resources that would otherwise have to be spent on our own measurements.

We distinguish:

- **analog sources** - most often paper maps that we have to scan or otherwise digitize into a computer image. Further processing of the image is its rectification (transformation of the coordinate system) and possible vectorization.
- **digital resources** - existing GIS files with map layers.

... they contain errors already obtained during the first data processing, so they cannot be more accurate than the primary sources being processed.

Analog sources can be converted to digital form by **digitization**.

When digitizing paper map documents, we basically solve two tasks:

1. **Refine (geocoordinate, georeference) scanned image** - we need to give the image the character of a map, which means first of all to place it somewhere in geographical space.
2. **Vectorize selected objects** in the image - extract some additional vector layers from the image.

Georeferencing - transformation of image coordinates to GIS geographic/cartographic coordinates - via **reference points**.

Thank you for your attention.