IGSSE Forum Raitenhaslach, 26 June 2013

Basic concepts and challenges of remote sensing

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with contributions from

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What is Remote Sensing?

Definition: Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object.

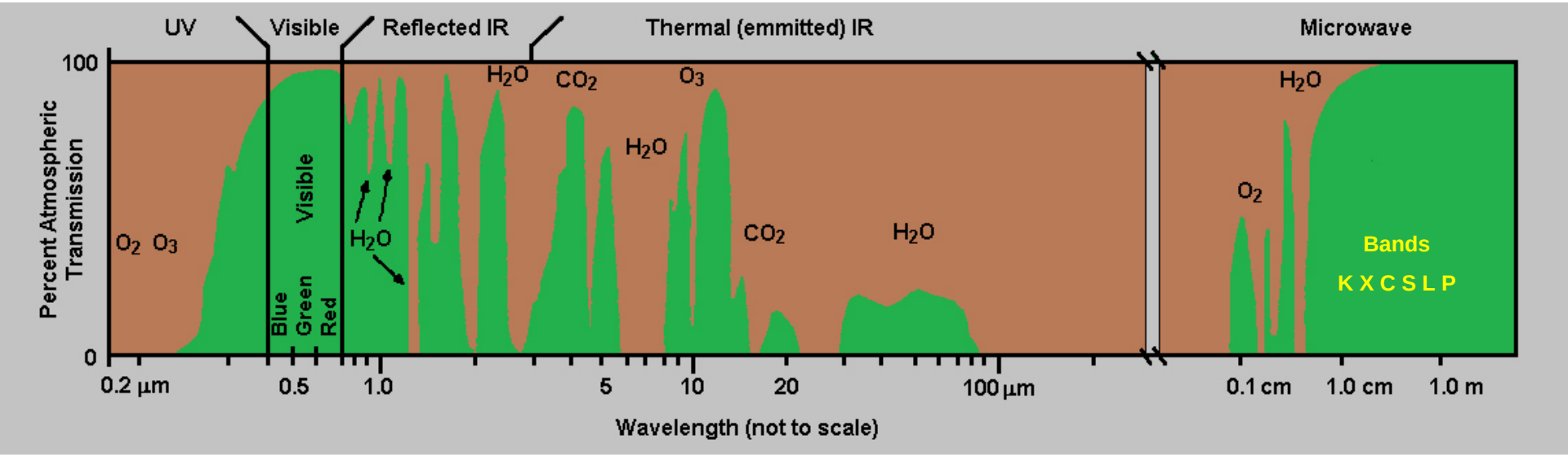
Remote sensor

In modern usage, the term generally refers to the use of aerial or satellite sensor technologies to detect and classify objects on Earth (in the atmosphere, on the surface, in water).

Sputnik 1

Useful Wavelengths

- Remote sensing of most atmospheric components makes use of their absorption properties.
- Remote sensing of the Earth surface from satellite is restricted to the **atmospheric windows**.

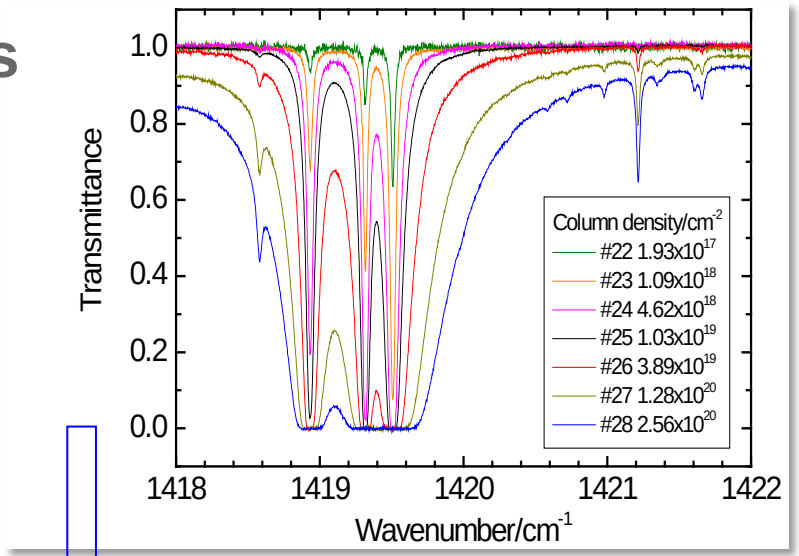


Paul R. Baumann (2010). http://www.oneonta.edu/faculty/baumanpr/geosat2/RS-Introduction/RS-Introduction.html

Useful Wavelengths

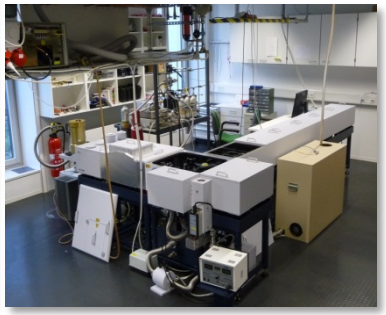
Atmospheric components

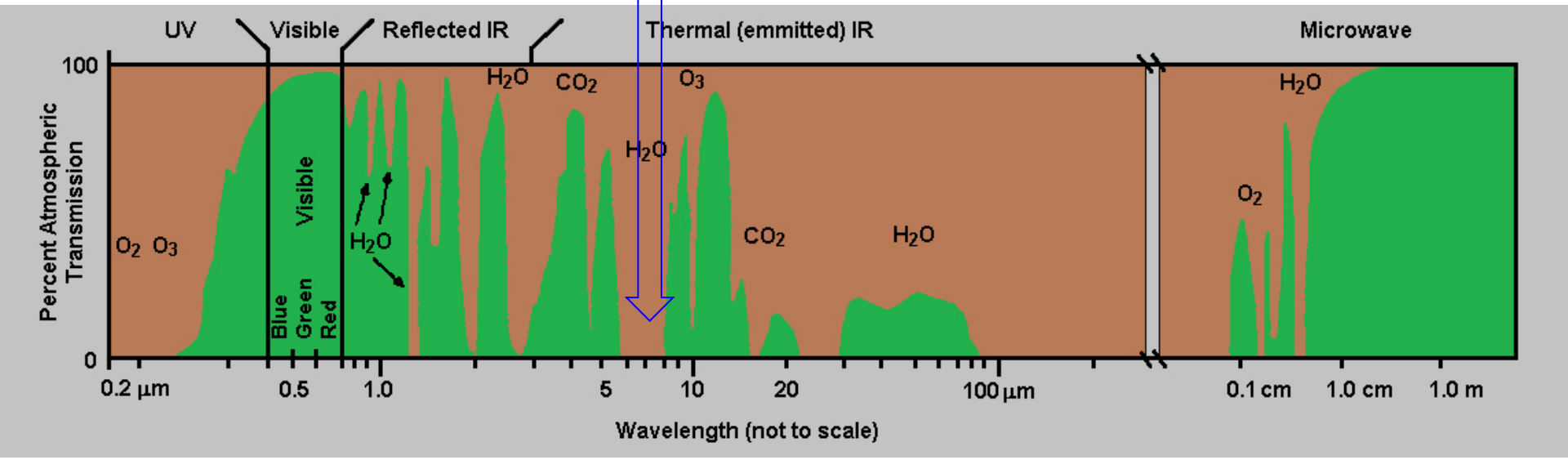
Remote sensing requires detailed knowledge of optical properties



H_2O

FT spectrometer at DLR

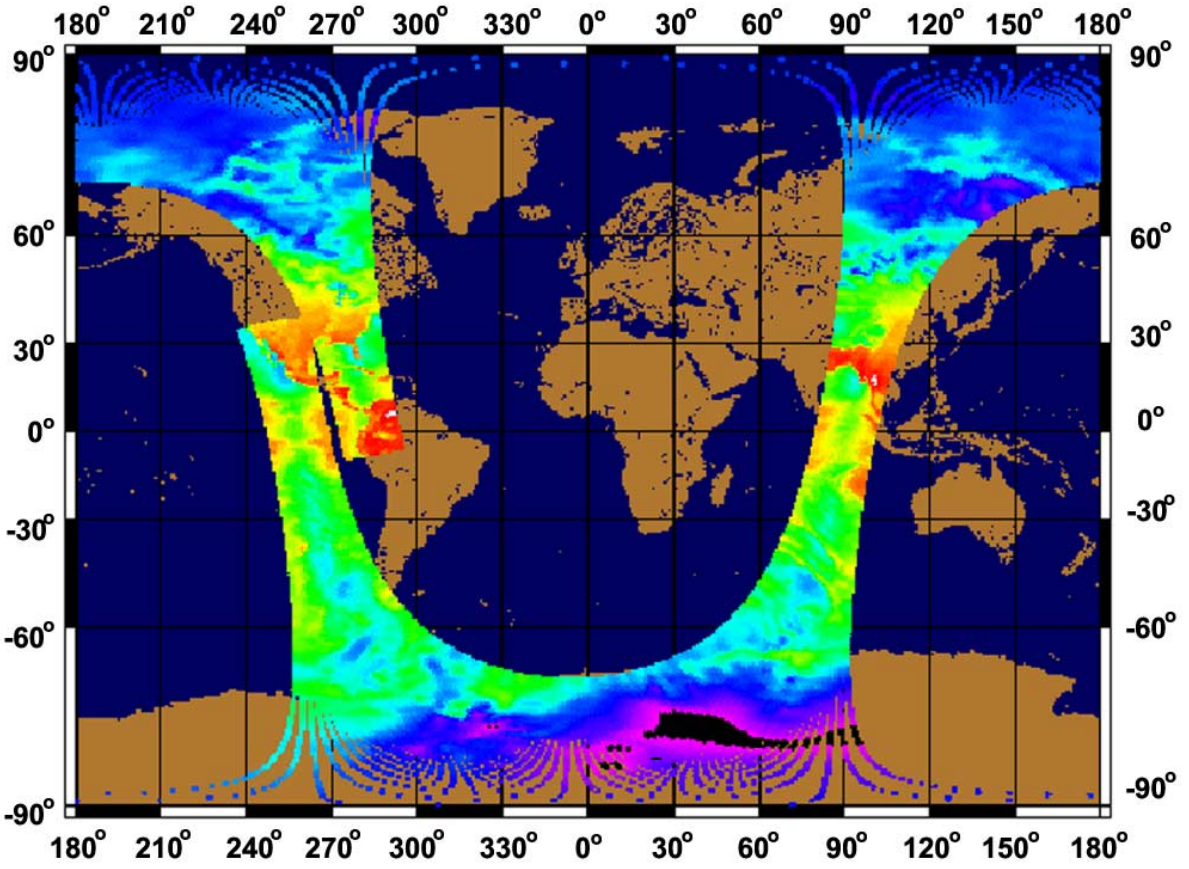


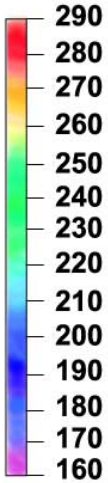


Paul R. Baumann (2010). http://www.oneonta.edu/faculty/baumanpr/geosat2/RS-Introduction/RS-Introduction.html

Example: Microwave Humidity Sounder (MHS) on MetOp-A

Derives a 3D picture of atmospheric humidity
(5 channels ↔ 5 altitudes)





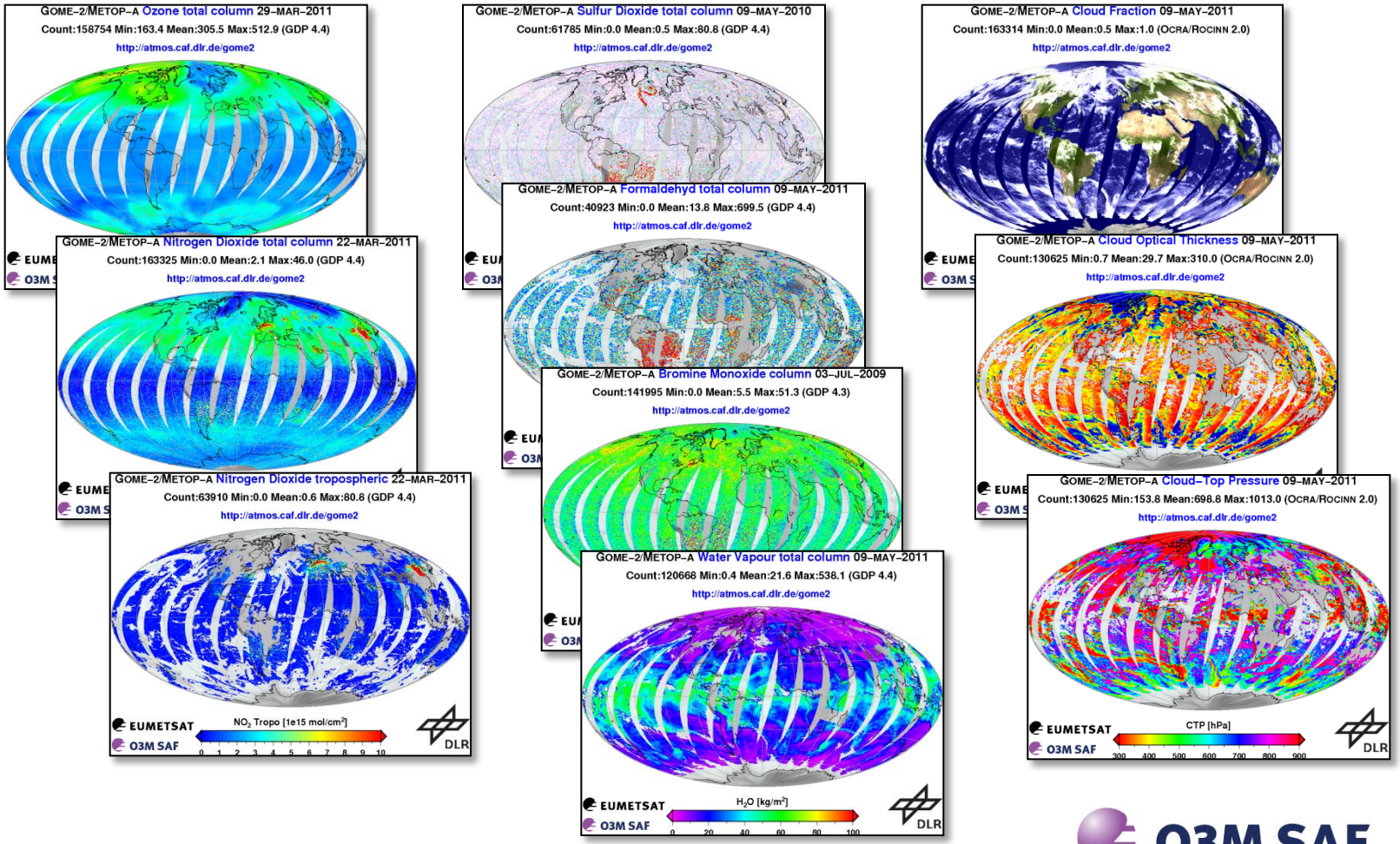
Water vapour concentration

Data acquired over one complete satellite orbit

Channel 1 (89 GHz = 3 mm)

Example: Global Ozone Monitoring Experiment-2 (GOME-2) on MetOp-A

Long-term monitoring of atmospheric trace gas constituents



Products
24/7
2h NRT

2007 - 2012

- O_3 tot.
- NO_2 tot.
- NO_2 trop.
- SO_2
- HCHO
- BrO
- H_2O
- Clouds

O3M SAF

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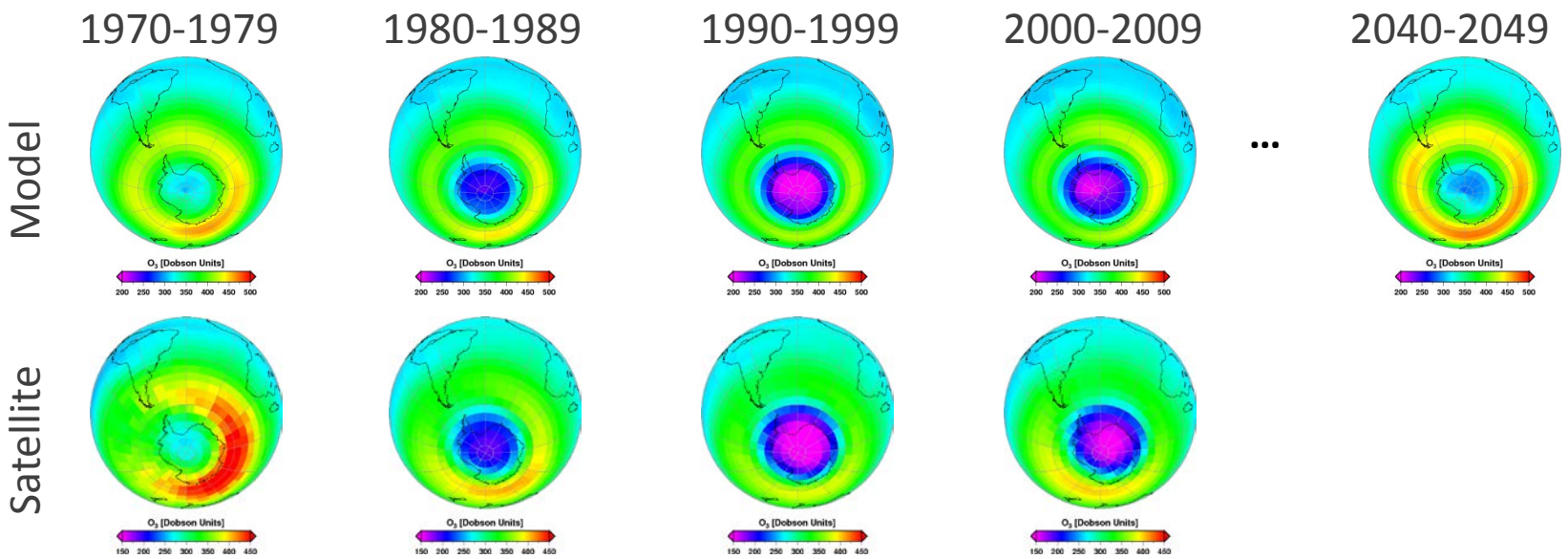
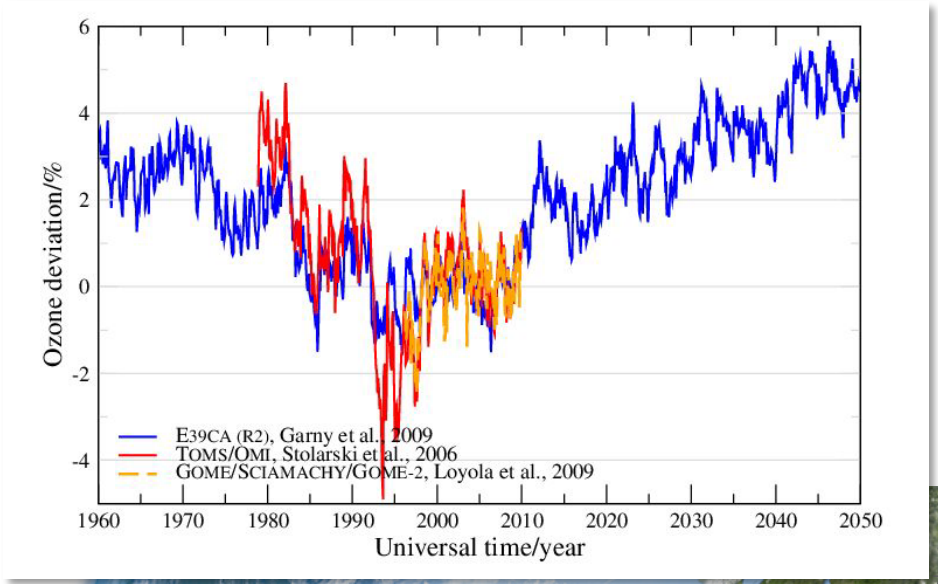
Copernicus
The European Earth Observation Programme

Example: Monitoring and Prediction of the Ozone Layer



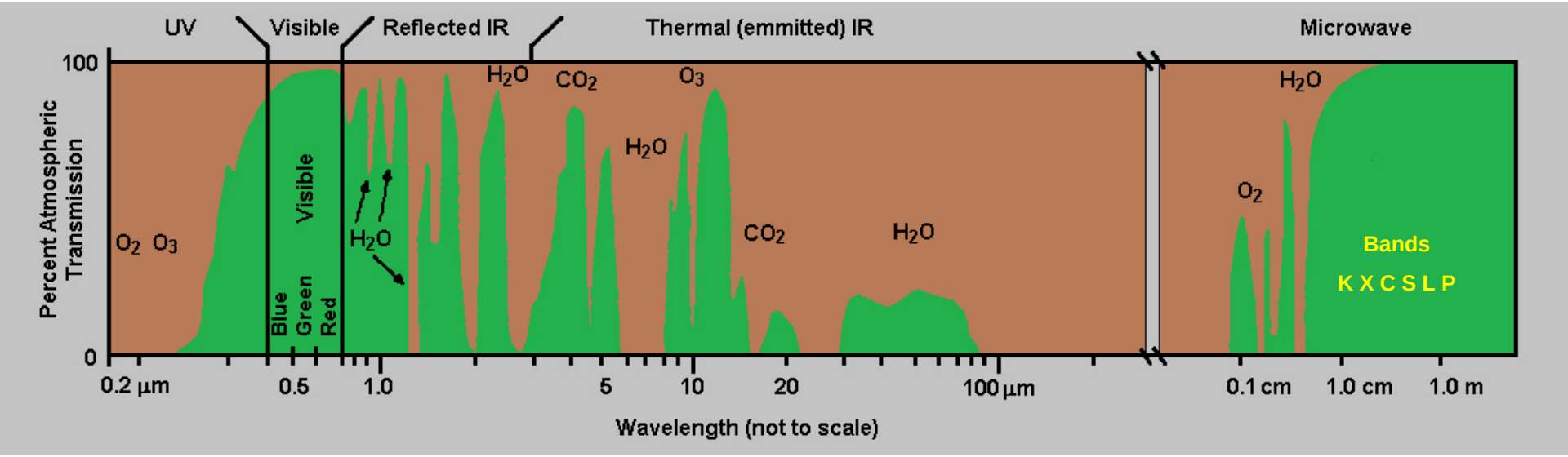


Useful Wavelengths

Earth surface

Remote sensing can utilize the **atmospheric windows**

Information is derived from geometry, surface structure, spectral properties, penetration depth



Paul R. Baumann (2010). http://www.oneonta.edu/faculty/baumanpr/geosat2/RS-Introduction/RS-Introduction.html

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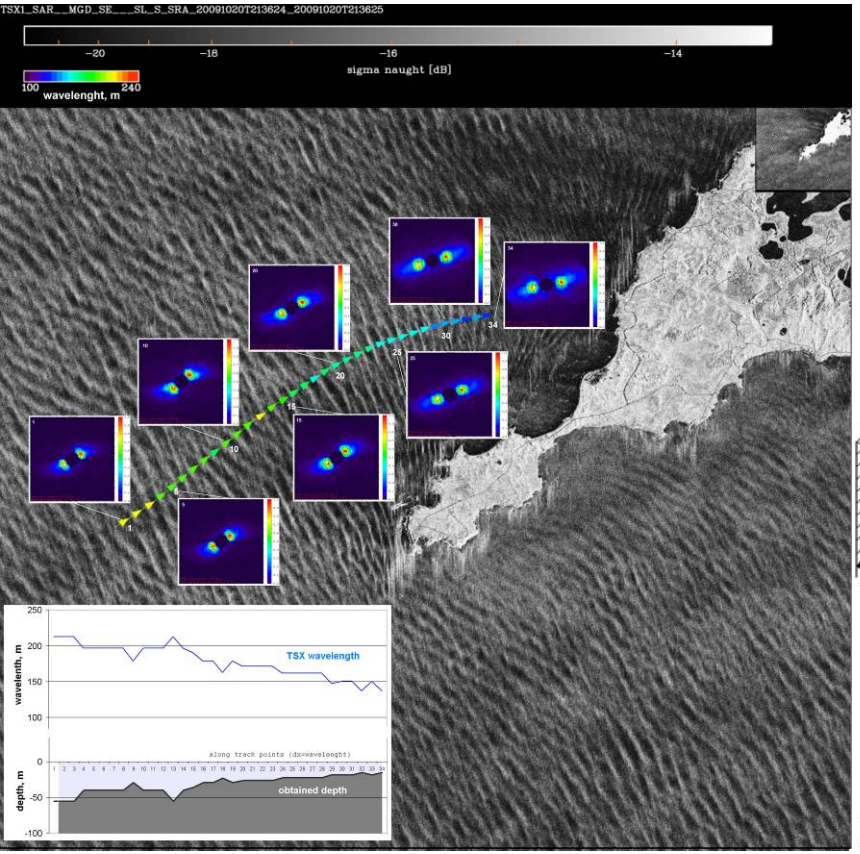
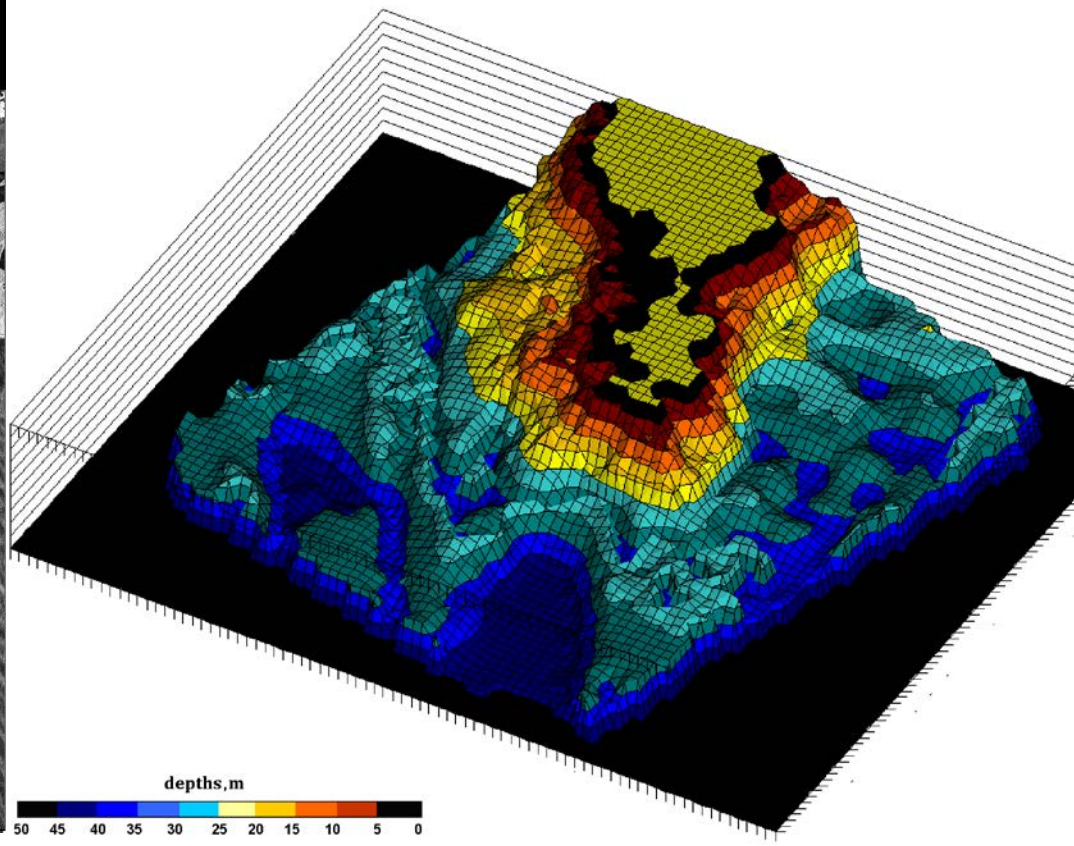
Example: Digital Elevation Model from Stereo Images

3D model of London derived from 5 viewing angles

Example: Bathymetry from Ocean Wave Patterns

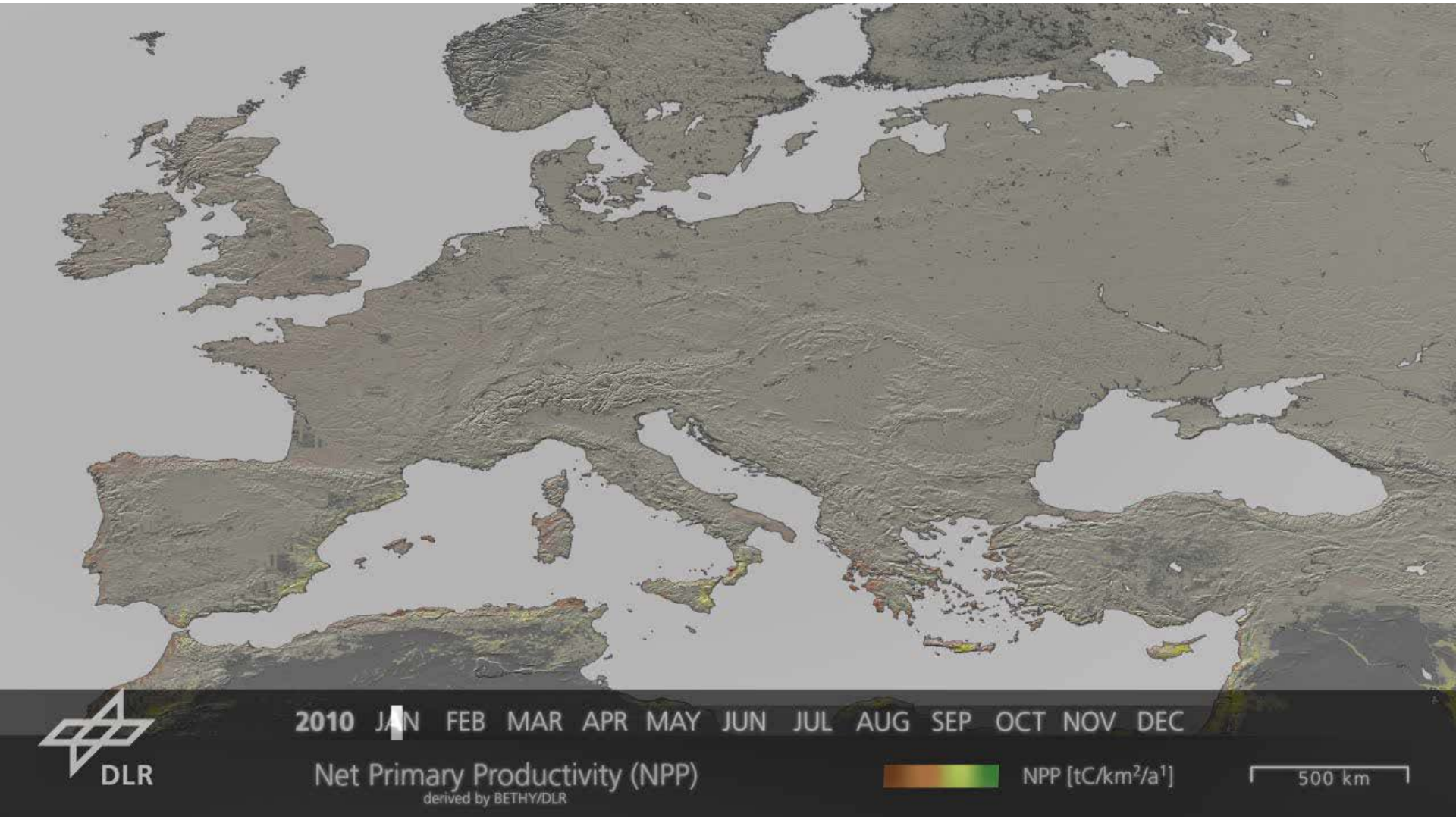
Water depth near coastline, used e.g. to predict tsunami propagation





Example: Biological Parameters from Spectral Properties

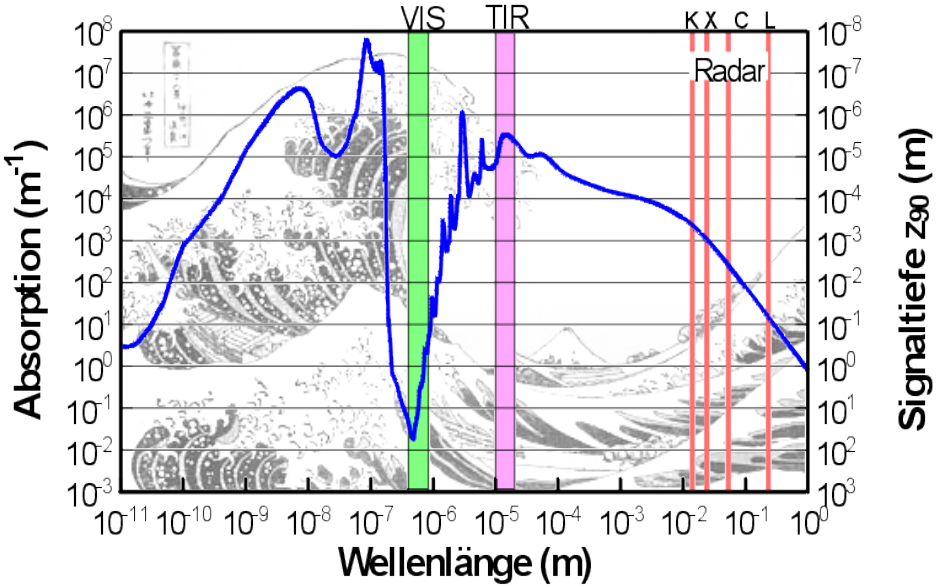
Temporal development of plant productivity

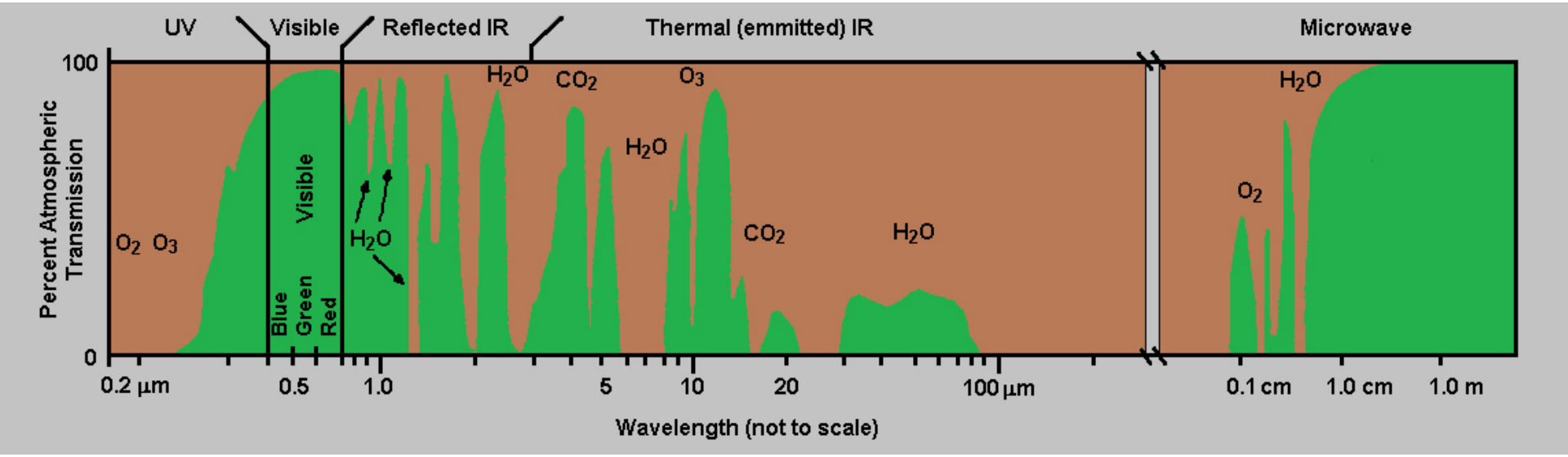


Useful Wavelengths

Water constituents

Water is transparent only in the visible and near UV





Paul R. Baumann (2010). http://www.oneonta.edu/faculty/baumanpr/geosat2/RS-Introduction/RS-Introduction.html

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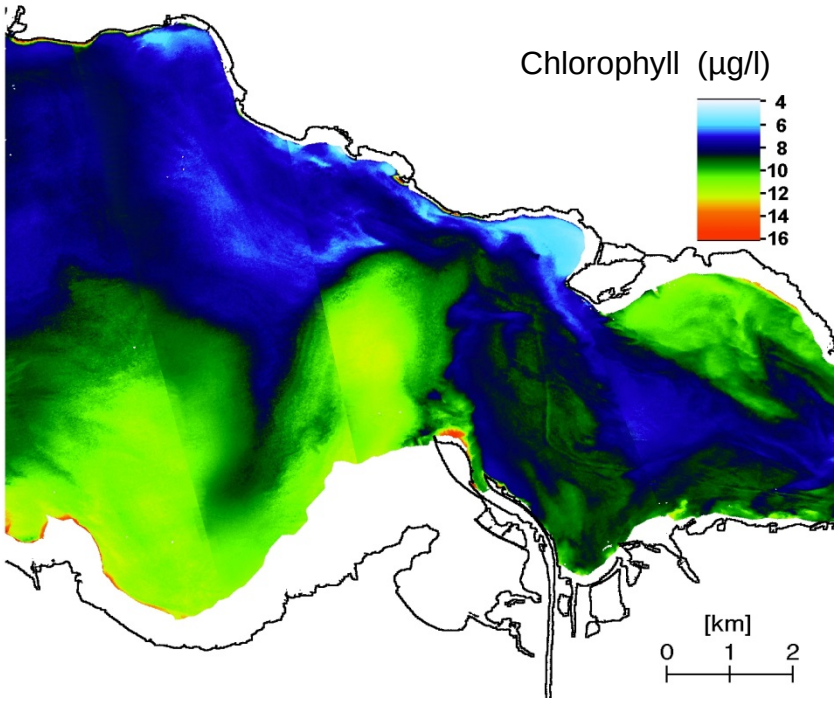
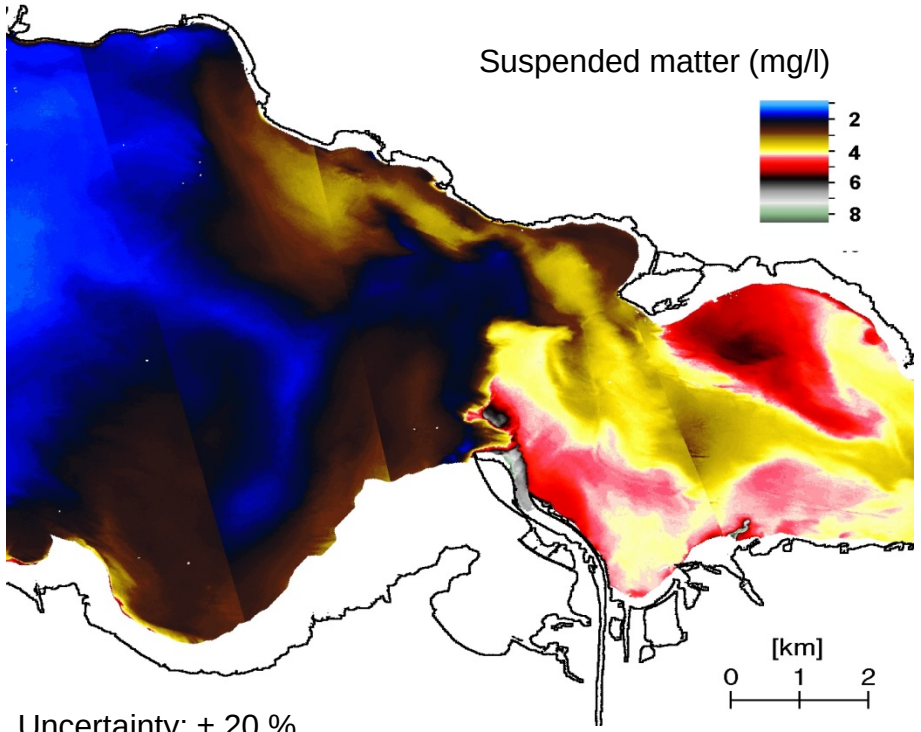
Example: Chlorophyll and Suspended Matter

Results of an airborne campaign in Lake Constance (Bodensee)



Uncertainty: ± 17 %



Uncertainty: ± 20 %

T. Heege (2000): Flugzeuggestützte Fernerkundung von Wasserinhaltsstoffen am Bodensee. Dissertation. DLR-Forschungsbericht 2000-40, 141 Seiten

T. Heege, J. Fischer (2004): Mapping of water constituents in Lake Constance using multispectral airborne scanner data. *Can. J. Remote Sensing*, Vol. 30, No. 1, pp. 77–86

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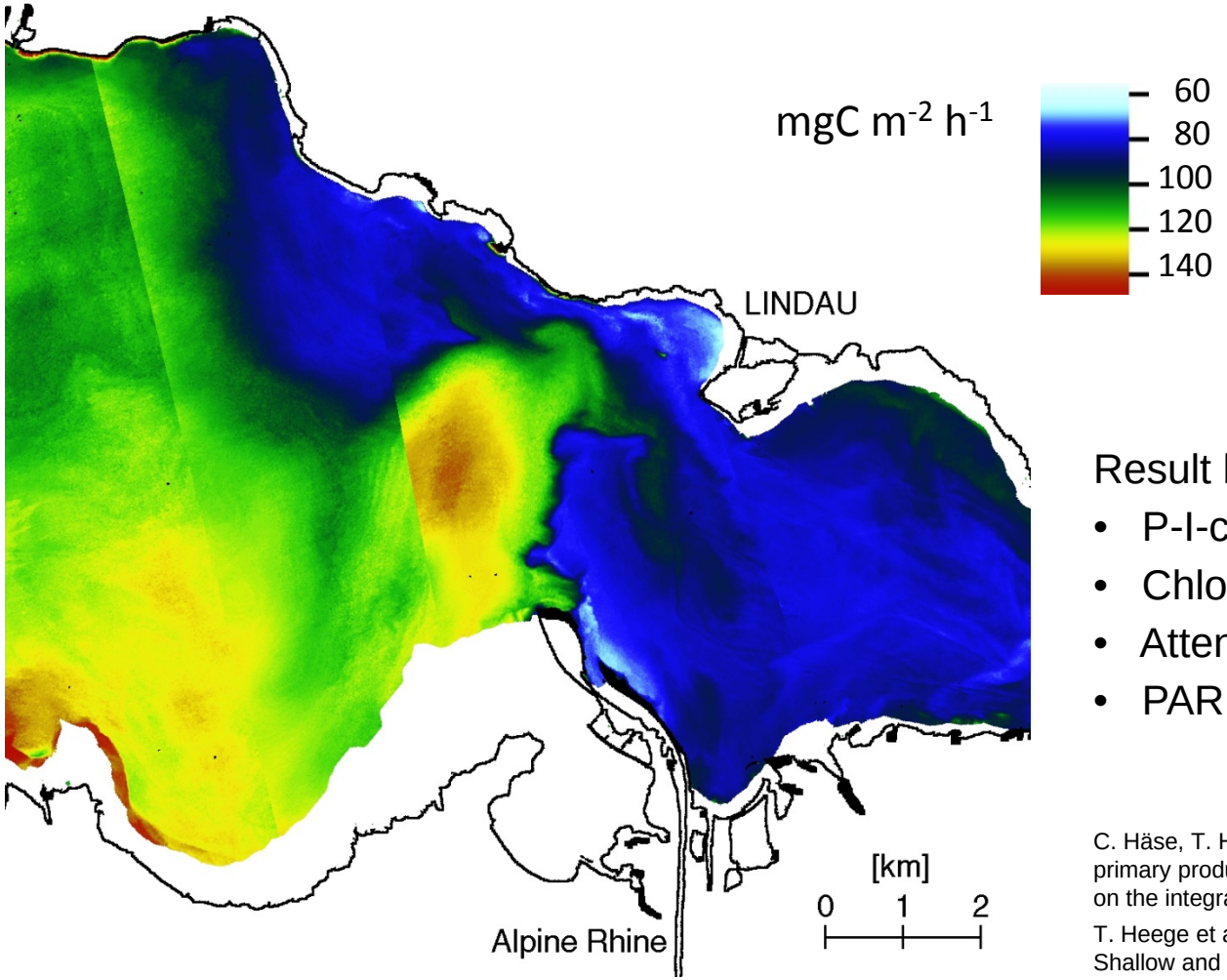
Example: Primary productivity

Results of an airborne campaign at Lake Constance (Bodensee)



Result based upon

- P-I-curves from 15 years
- Chlorophyll
- Attenuation (from Chl, Y, SPM)
- PAR

C. Häse, T. Heege (2003): A remote sensing algorithm for primary production in Lake Constance with special emphasis on the integration level. ENVOC Final Report, March 2003.

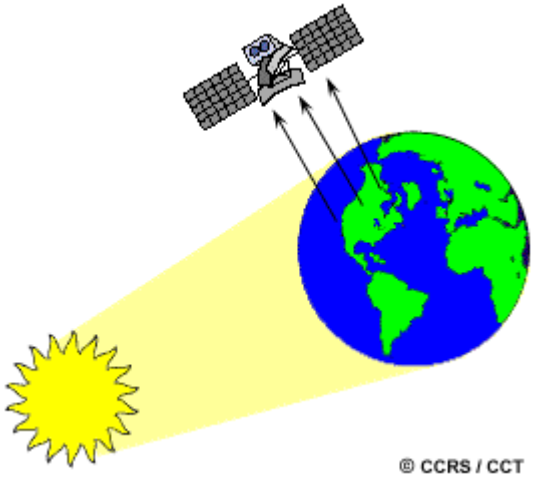
T. Heege et al. (2003): Airborne multi-spectral sensing in Shallow and Deep waters. Backscatter Vol. 14, No.1, 17-19.

Sensor Types

Passive Sensors

Passive sensors detect natural radiation that is emitted or reflected by the object or surrounding areas.

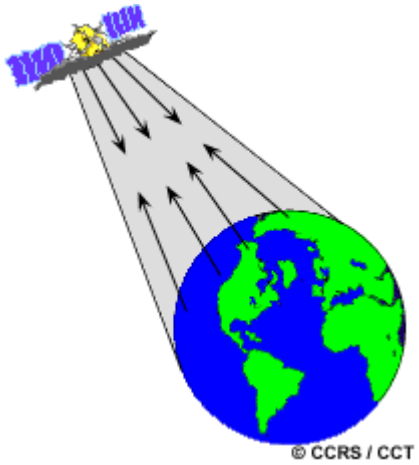
Examples: CCD cameras, infrared sensors, imaging spectrometers.



Active Sensors

The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor.

Examples: RADAR, LIDAR.



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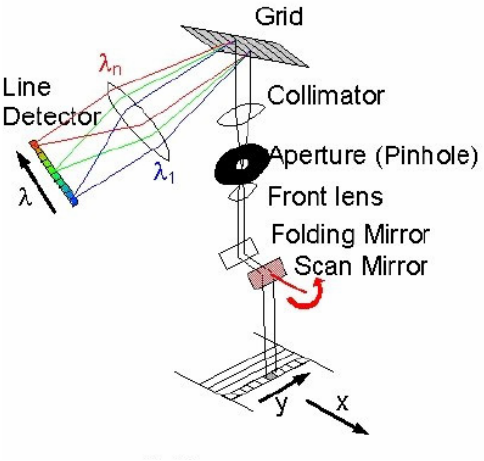
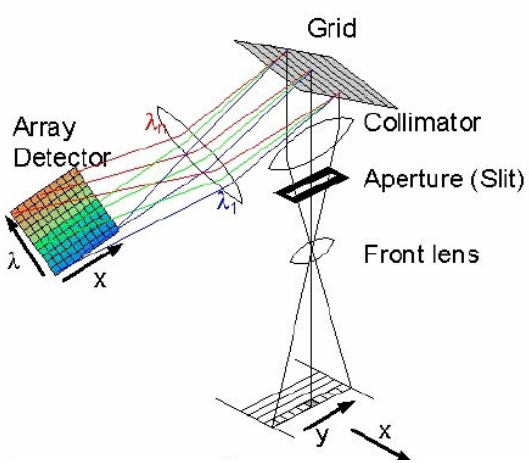
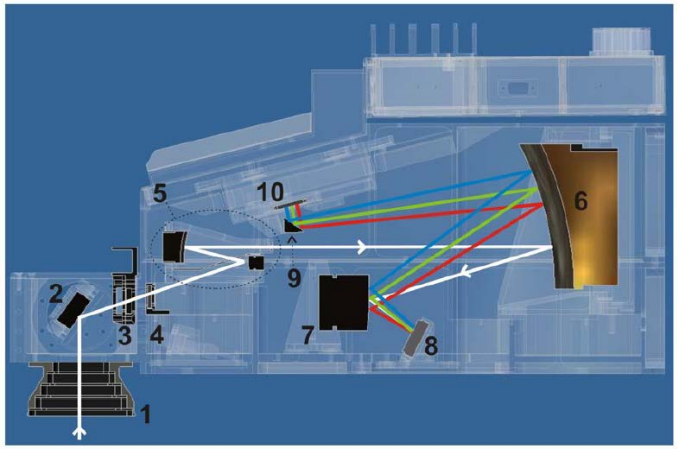
Example for passive sensors: Hyperspectral Sensors

Imaging spectrometers allow spectroscopy by remote sensing





Airborne sensor ROSIS



Whiskbroom Scanner

Simultaneously recorded:
N channels = 1 spectrum

Pushbroom Scanner

Simultaneously recorded:
N channels x M pixels =
M spectra of 1 image line

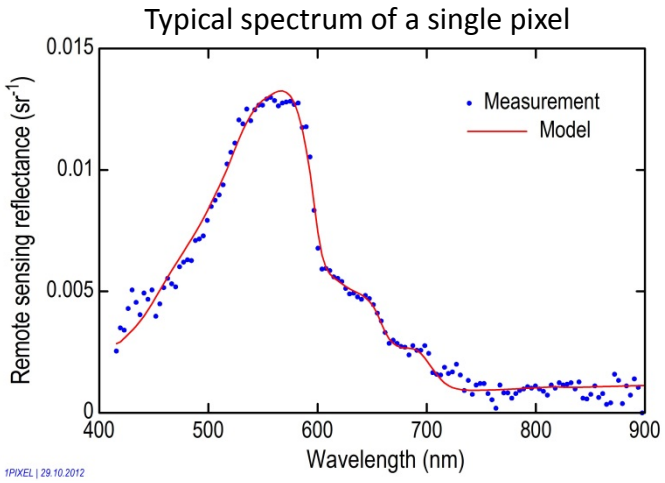
Airborne sensor HySpex

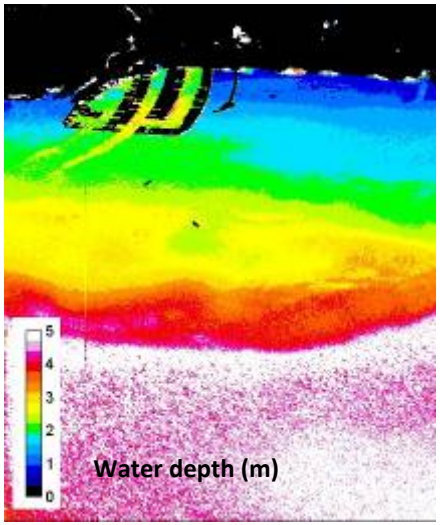
Example for Hyperspectral Applications

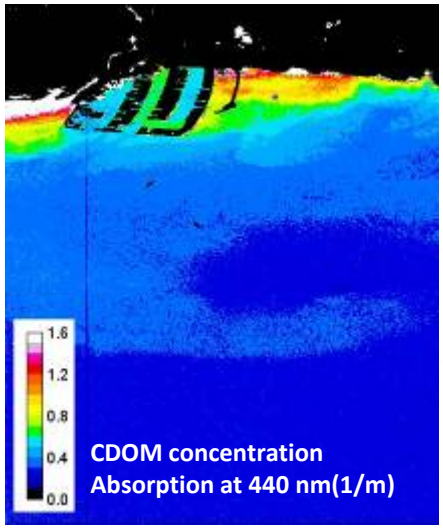
Remote sensing of shallow water areas

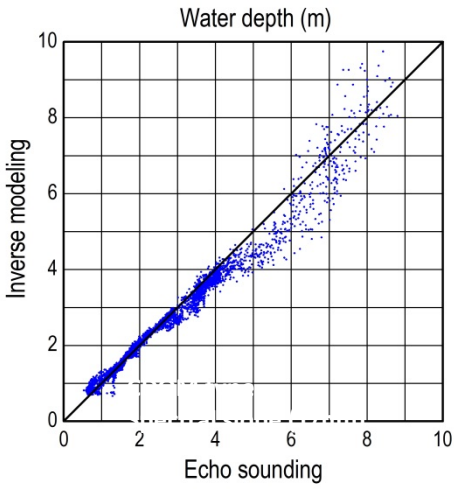
Atmosphere corrected with ATCOR-4

Inverse modeling with WASI-2D

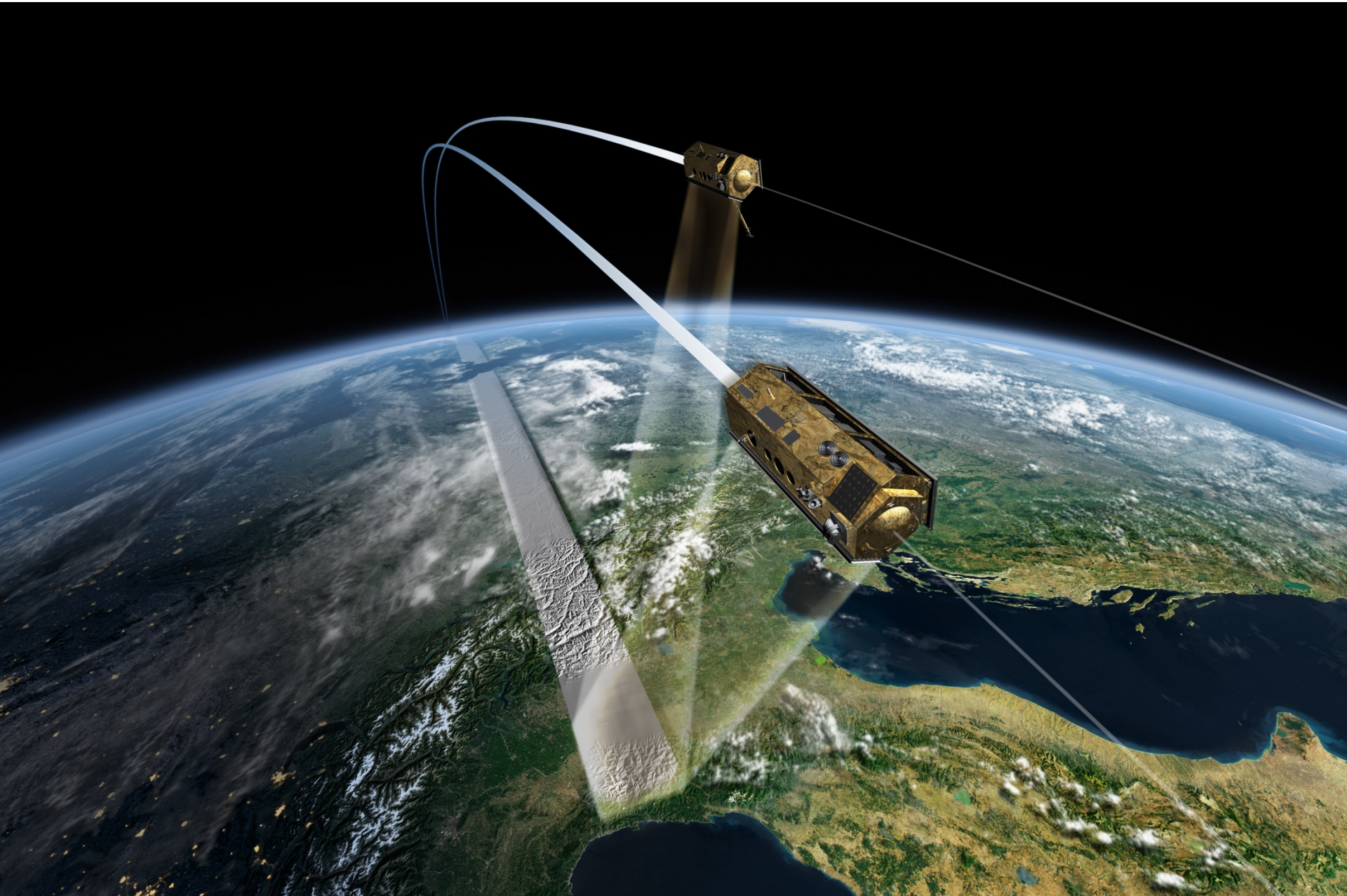


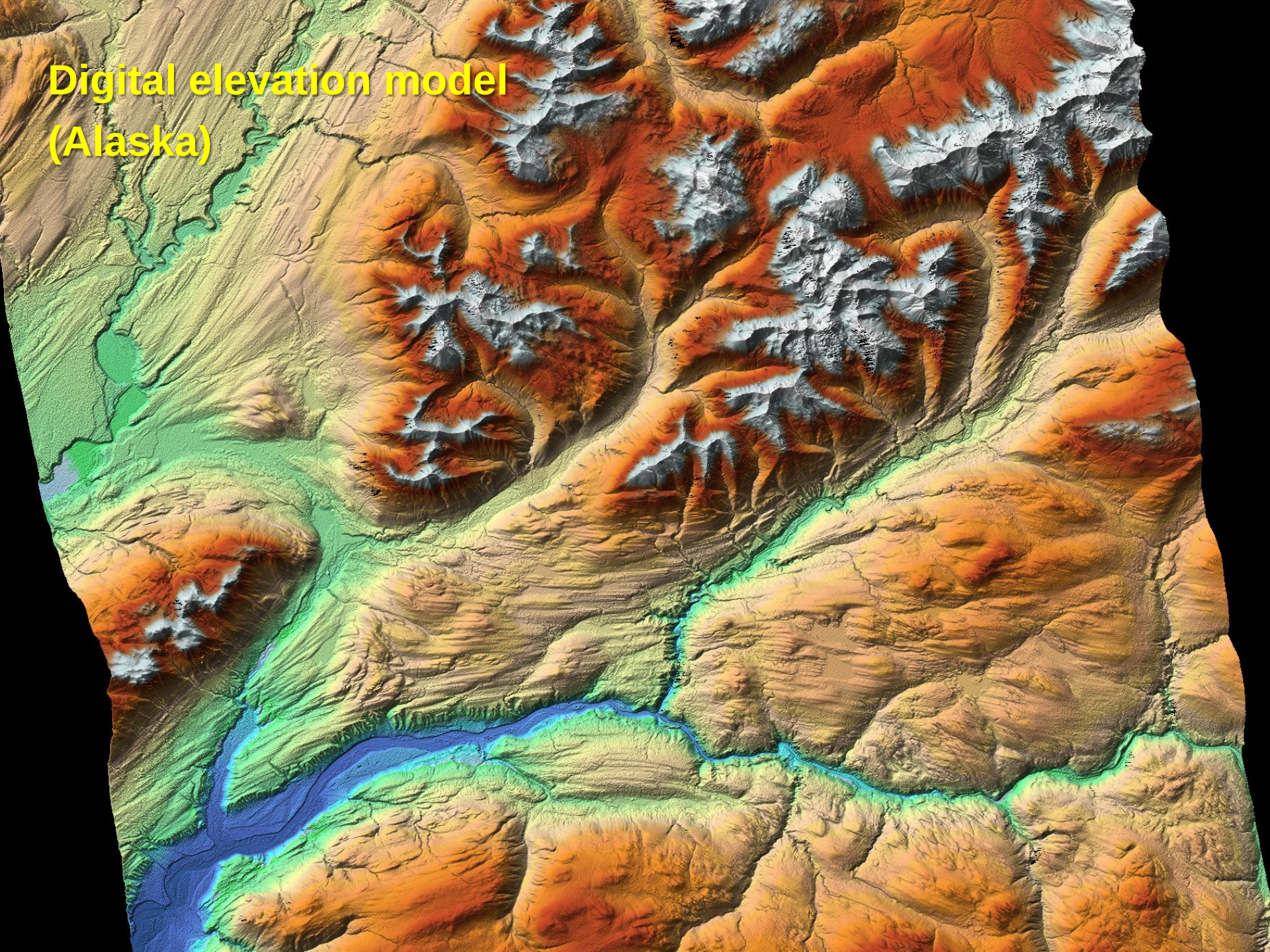






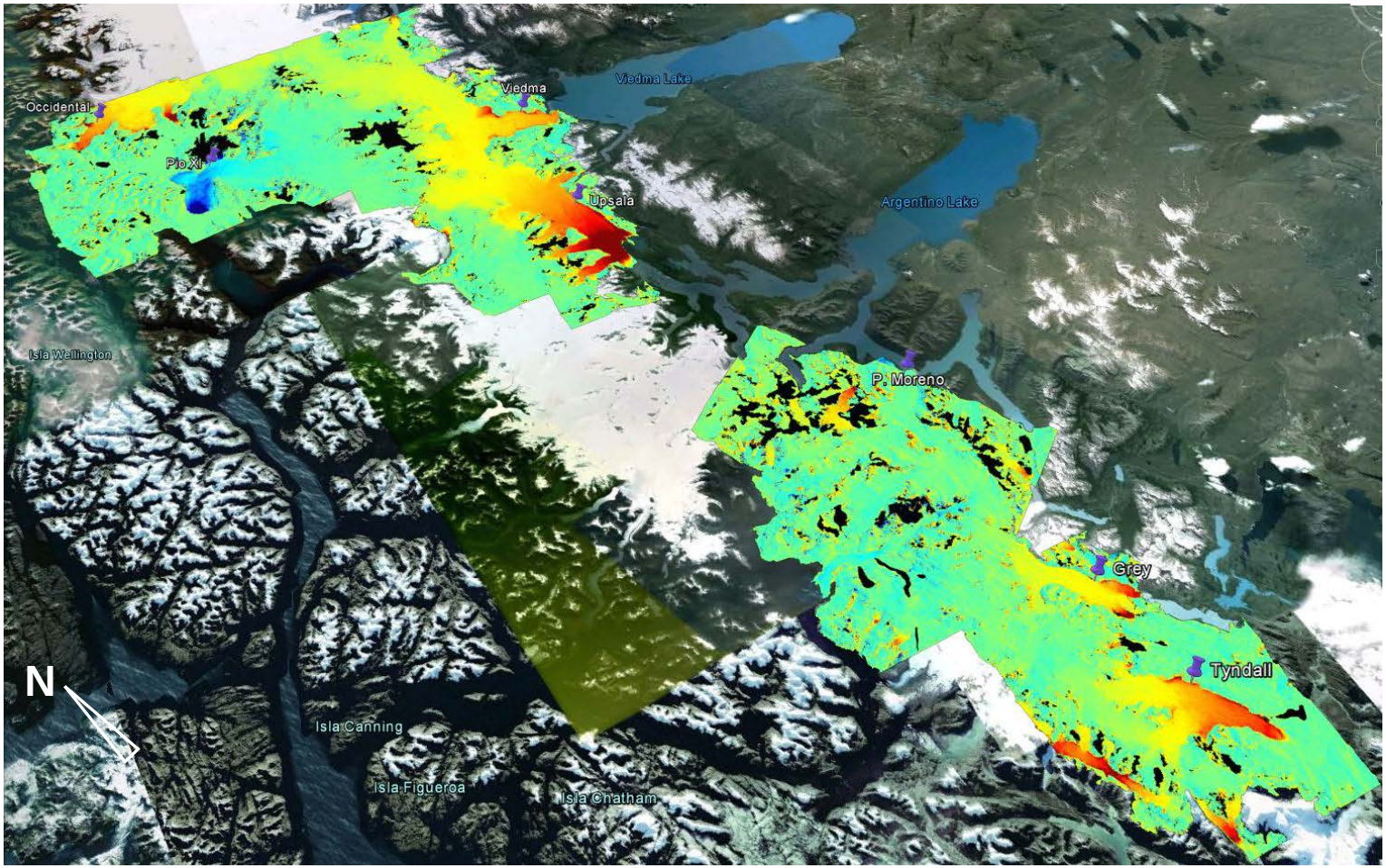
Example for active sensors: TerraSAR-X and Tandem-L




Digital elevation model
(Alaska)

Ice Thickness Changes from 2000 to 2011
South Patagonia Ice Field

DEM difference: TanDEM-X (2011) – SRTM (2000)



elevation change [m]

+100

0

-100

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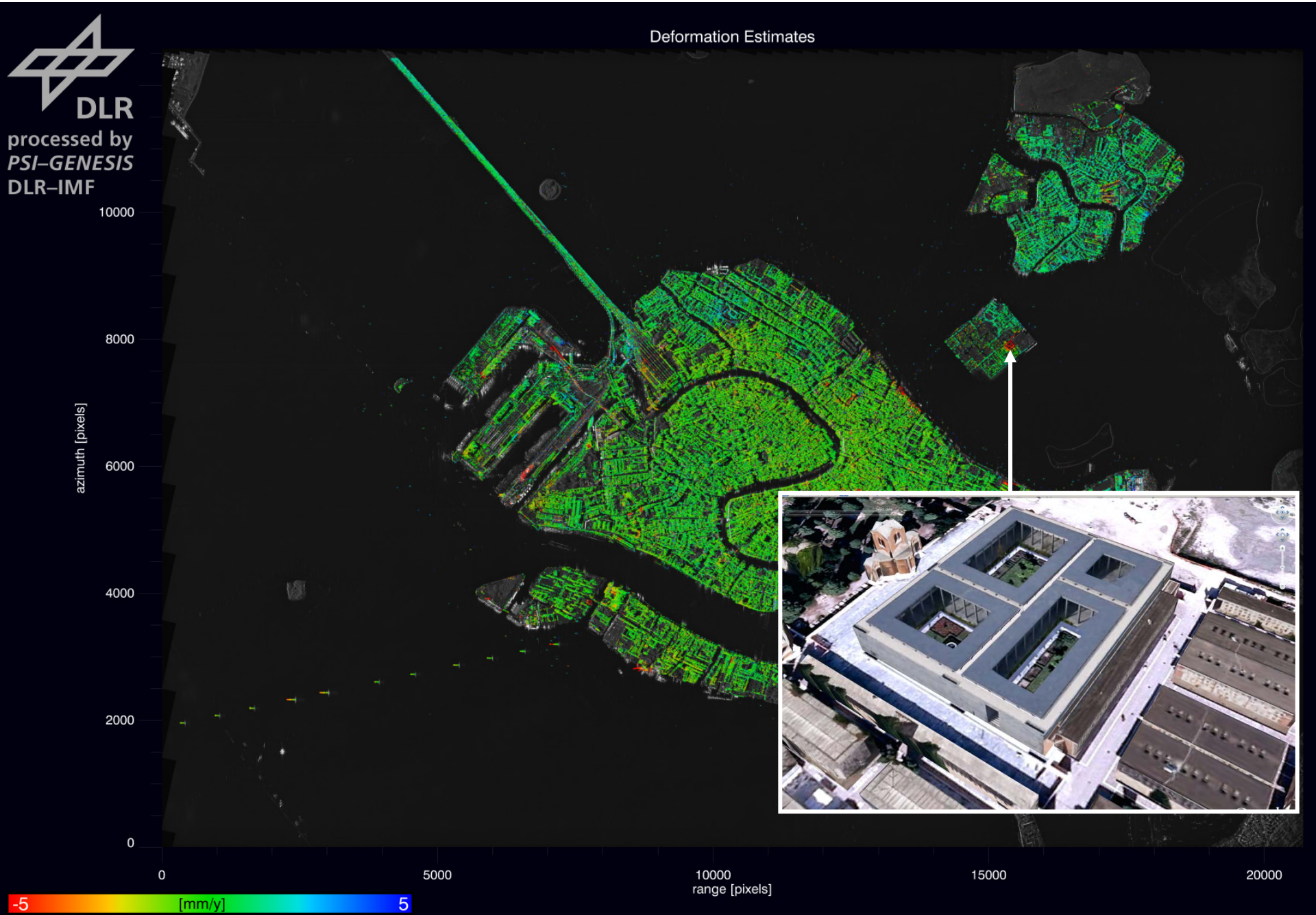
Subsidence in Venice



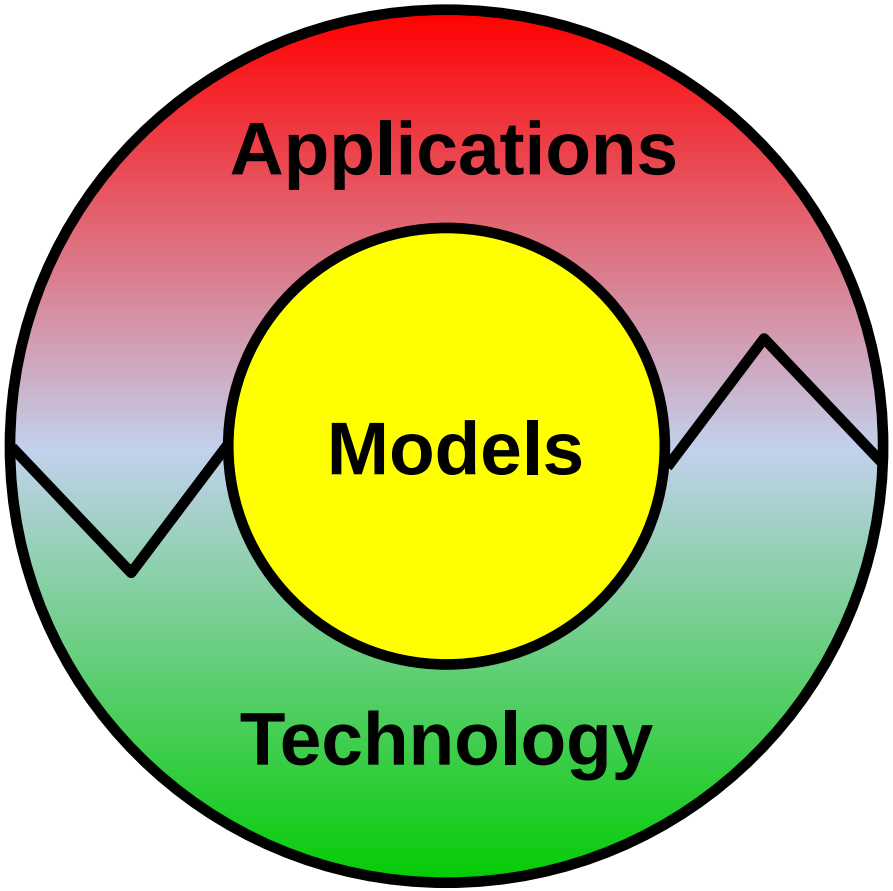
Challenges of Remote Sensing

... all this must be done properly to get the shown nice results

- Sensor development
- Sensor launch
- Sensor calibration
- Georeferencing
- Atmosphere correction
- Determination of optical properties
- Model development
- Inversion
- Validation
- ...

Modern Sysiphus by Dluho. toonpool.com

Concept of Remote Sensing



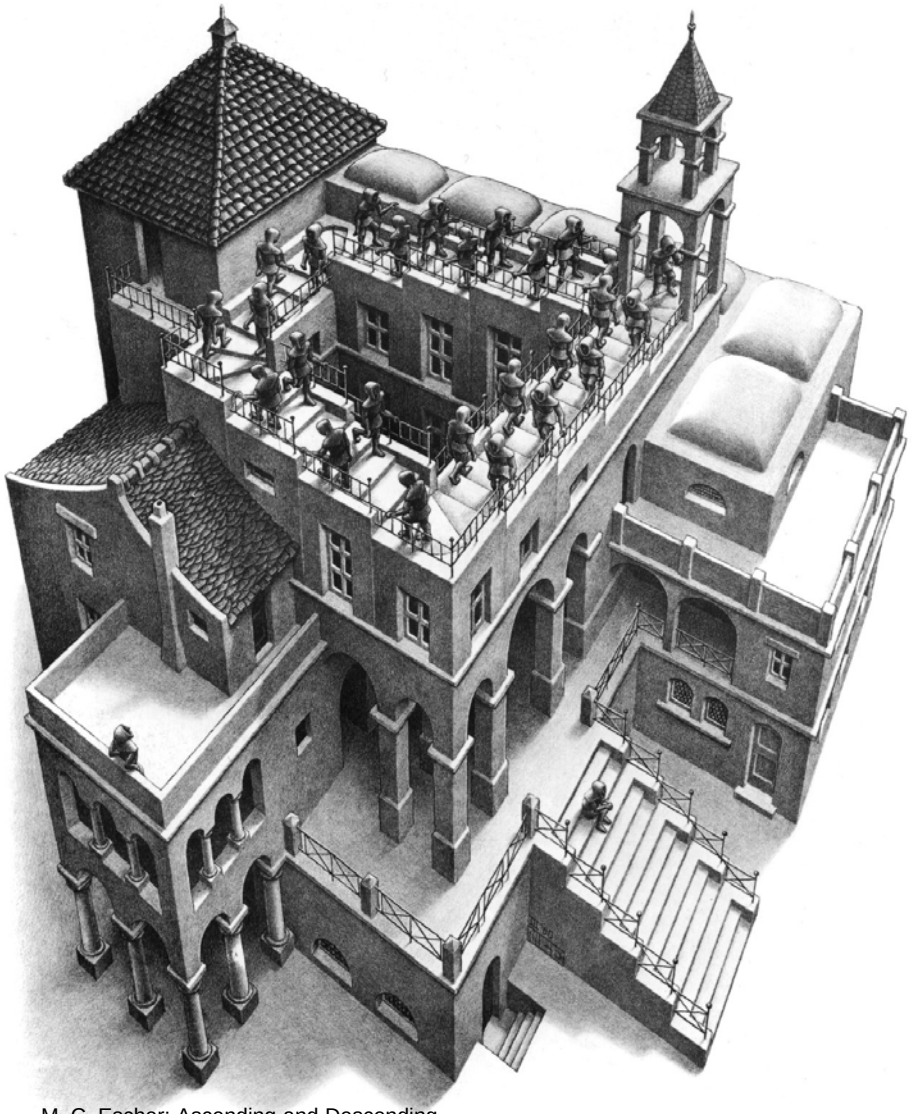
Develop sensors to answer specific questions

“It is the theory that decides what can be observed.” (A. Einstein)

Exploit information content of data sets

Concept of Remote Sensing

... and of much more, maybe also of Shaping interdisciplinary processes?



M. C. Escher: Ascending and Descending

Thank you for your attention!