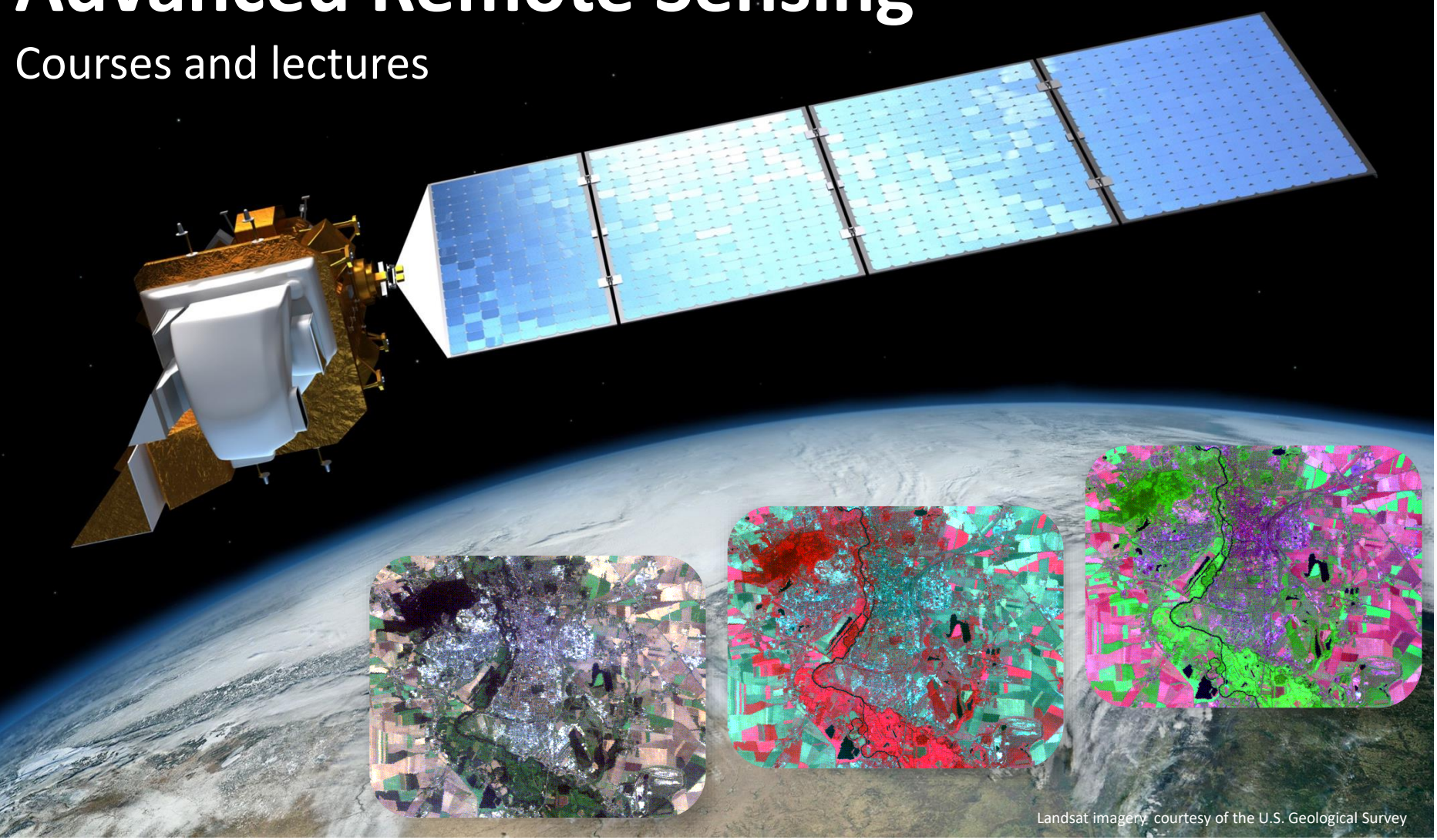
NASA/Goddard Space Flight Center Conceptual Image Lab

Advanced Remote Sensing

Courses and lectures



Landsat imagery courtesy of the U.S. Geological Survey

Martin Luther University Halle-Wittenberg
Institute of Geosciences and Geography
Department of Remote Sensing and Cartography

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Background

- Consecutive courses and lectures, however…
- Heterogeneous student body in the MSc courses – students…
  - … from different universities
  - … from different study courses
  - … with different levels of know-how
- Geomatics MSc lecture

  → Basic lecture in advanced RS & geospatial data analysis

  → followed by advanced courses for deepening of theoretical and practical knowledge in RS and spectral measurements within different fields

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Advanced Remote Sensing MSc courses

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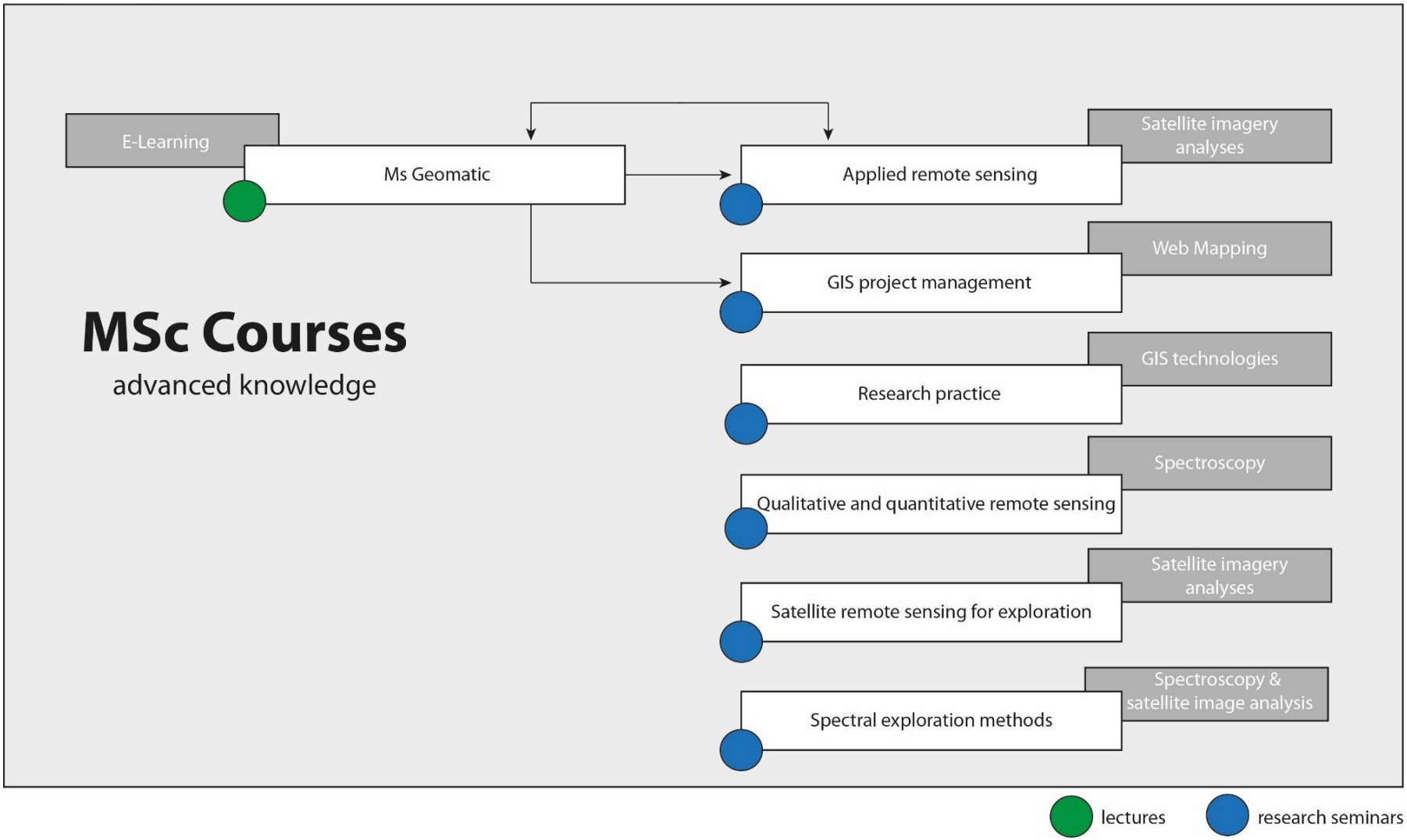
HALLE-WITTENBERG



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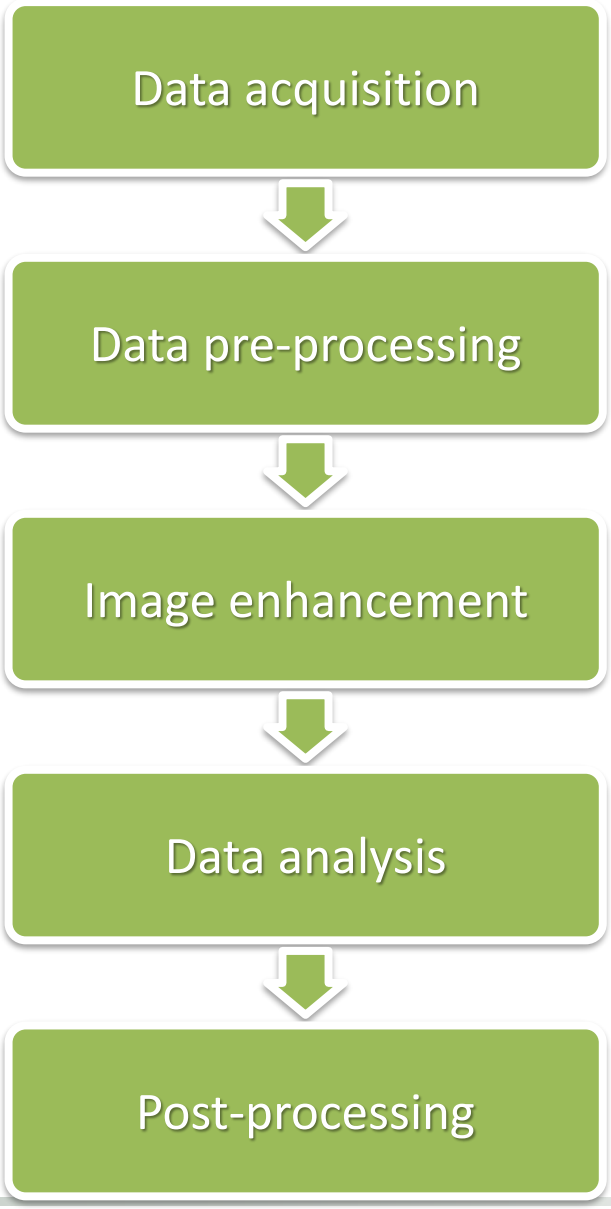
Aims of the advanced RS courses

- Teaching of in-depth theoretical knowledge
- Training in literature search and handling
- Going through the whole chain from data search and acquisition to data analysis and interpretation using one thematic example
- Advanced skills in instrument handling, data processing and analytics

→ **Preparation of the students for the needs of the labour market**



Didactic approach

- Each year different topics associated to the department´s research projects
- Number of students ~10-15
- Teamwork in small groups of 3-5 students → involvement of students with different background and different levels of expertise/experience
- Only few “classical” lectures
- Focus on practical work
- Students working independently
- Presentations of the students – intermediate and final results
- Final report (in groups)

- Use of free and commercial data (Sentinel data, Landsat data, WorldView, etc.)
- Use of free and commercial software (R, QGIS, ERDAS Imagine, ESRI Suite, …)
  → see the list of free and commercial software!
- Training in modern field and laboratory methods

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Overview of thematic topics in the last year´s courses

- Change detection of post mining landscapes in Central Germany
- Assessing different vegetation units and their phenology in Israel
- Spectral analysis of floodplain vegetation for vegetation stress
- Spectral analysis of invasive plant species in Germany
- Spectral analysis and spatial mapping of laterites in Burkina Faso
- Mapping mining and industrial dump sites in Central Germany
- Mapping and monitoring crops
- …

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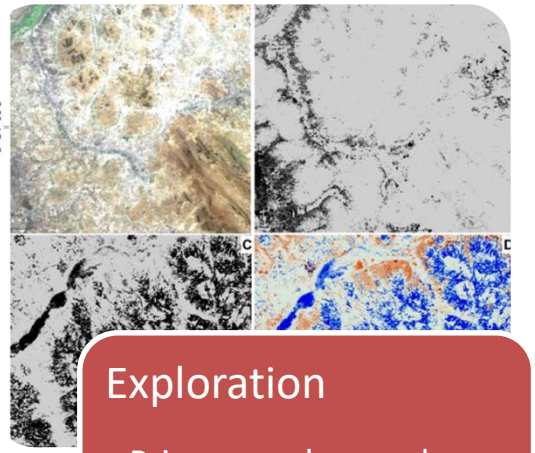
Example: Assessing changes in post-mining landscapes



Exploration

- Primary and secondary (“man made“) deposits
- Quali- and quantitative assessment of the raw material inventory

Active mining

- Monitoring of ongoing mining activities
- Mapping the spatial extend of mining areas, assessing potentiality

Reclamation

- Monitoring of bio- and geochemical processes
- Observation of mining lakes and hydrochemical parameters

Landsat imagery courtesy of the U.S. Geological Survey, Photos © RSC

Example: Assessing changes in post-mining landscapes

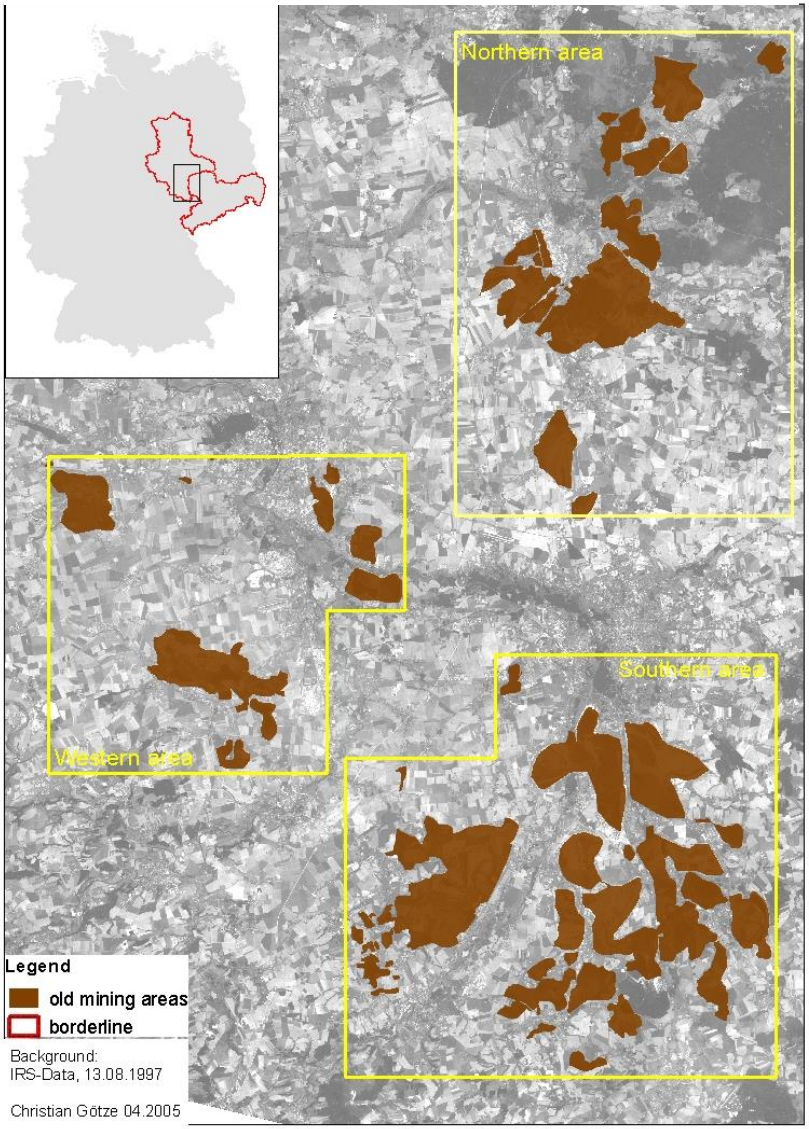
Background:

- Former lignite mining in Central Germany
- Flooding of open pit mines by ground-water rise or artificial water discharge
- Acid Mine Drainage due to sulfides in ore/ burden & other phenomena

Remote sensing key objectives:

- Multitemporal assessment of different flooding stages and other changes in LU

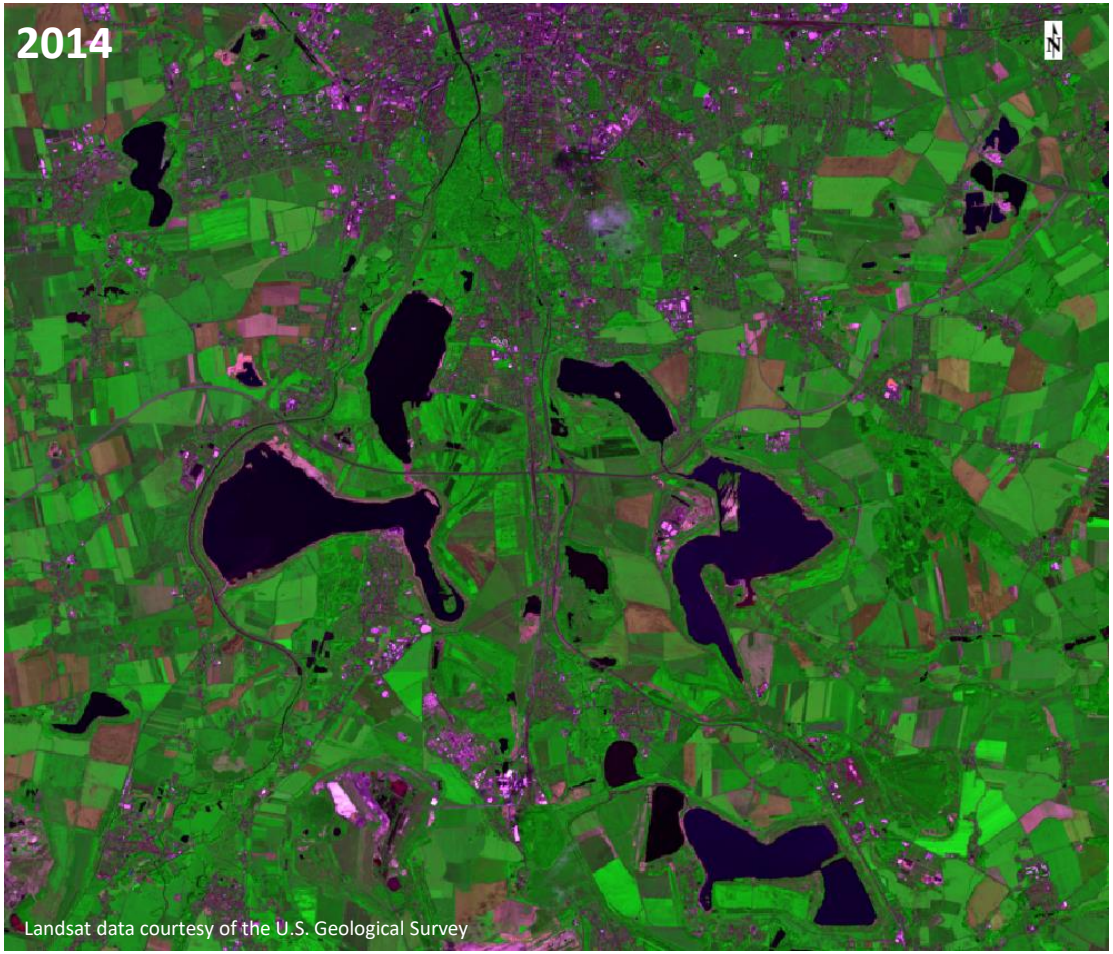
Central German open cast lignite mining area



Photos © RSC, Figure © Götze 2005

Example: Assessing changes in post-mining landscapes

Aim: Multi-temporal analysis of the development of the postmining landscape south to Leipzig using satellite data



Example:
Zwenkau open pit

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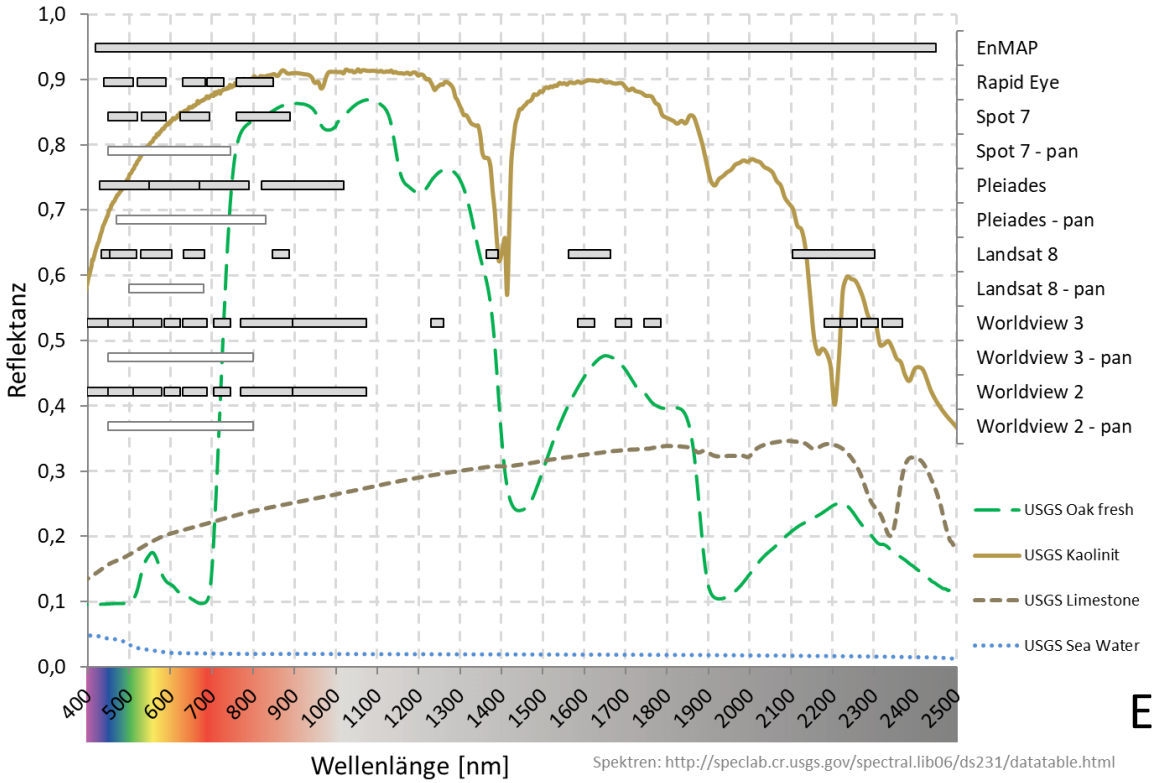
Example: Assessing changes in post-mining landscapes

Starting exercise: understanding satellite characteristics

- Different sensors and plattforms
- Different resolutions (spatial, spectral, temporal)



Spektren: http://speclab.cr.usgs.gov/spectral.lib06/ds231/datatable.html

EMS and sensor characteristics

Example: Assessing changes in post-mining landscapes

Providing knowledge on where and how to acquire satellite data:

Sentinel data:

- Copernicus Open Access Hub

Landsat archives and other data:

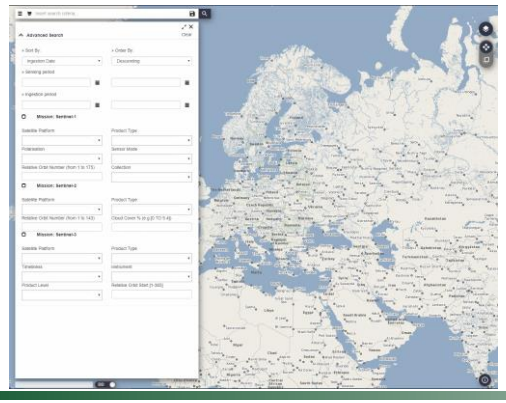
- USGS Earth Explorer, USGS Glovis, LandsatLook Viewer

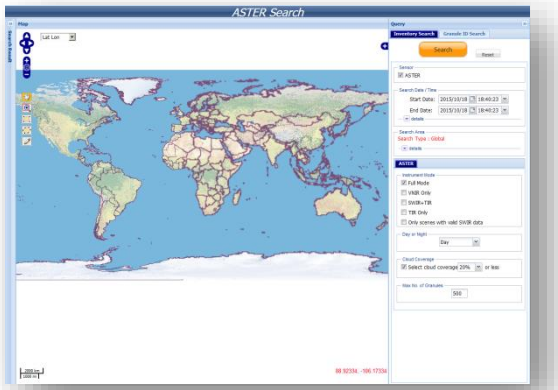
ASTER data

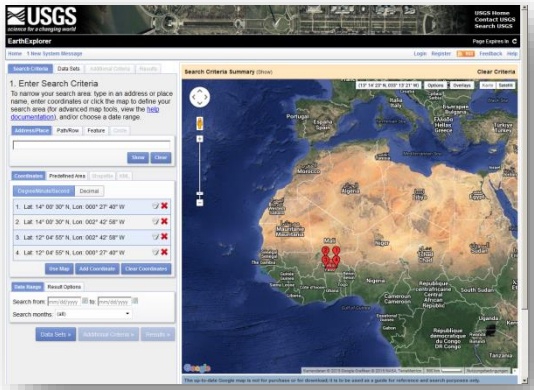
- ASTER FDS DAR system /ASTER/Palsar Unified Search

WorldView 1-3 and other data

- Digital Globe Image Finder







Example: Assessing changes in post-mining landscapes

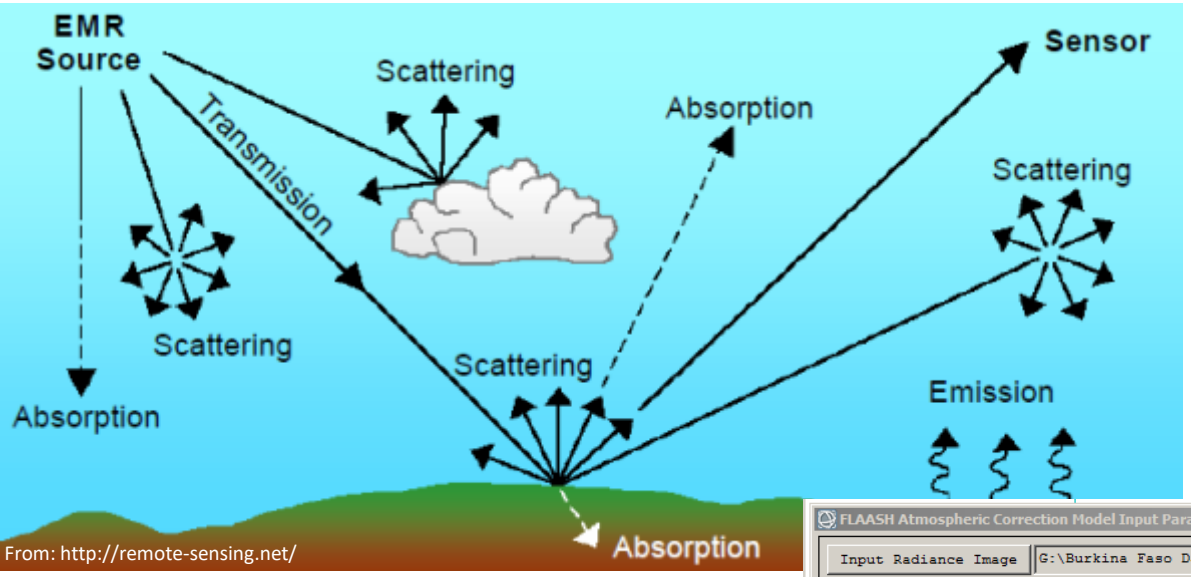
Discussion of the data quality and crucial issues for selecting data:

- Definition of the area
- Acquisition data
- Sensor type
- Cloud cover
- Vegetation cover & phenology
- Meteorological aspects
- Day/Night
- specific data-related issues, e.g. the Landsat-7-SLC-Off-problem
- …

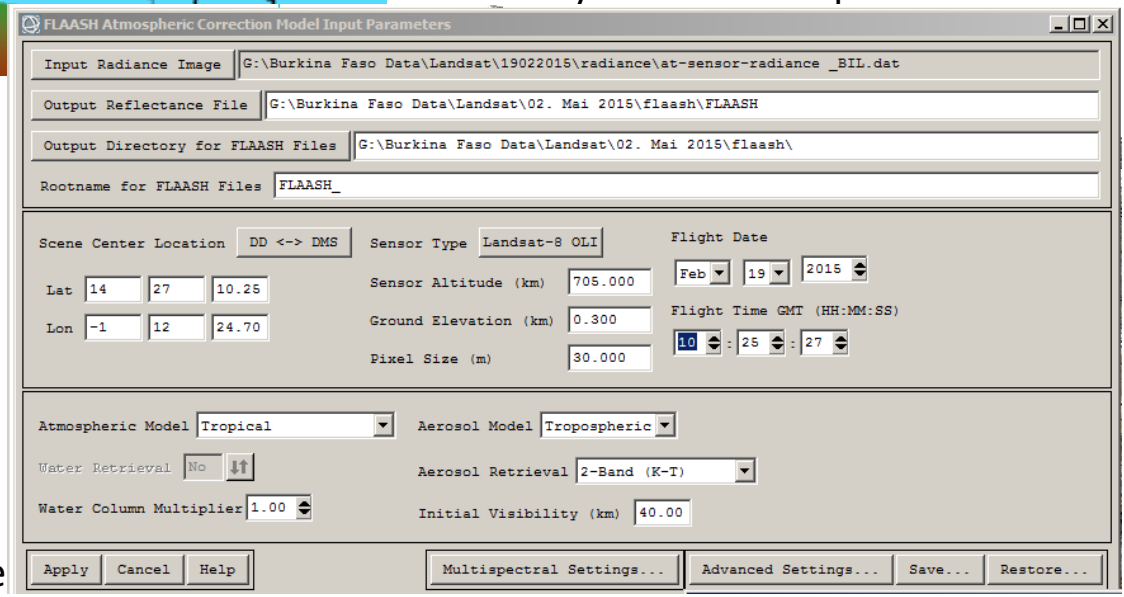
Landsat imagery courtesy of the U.S. Geological Survey

Example: Assessing changes in post-mining landscapes

Providing in-depth know-how on radiometric/atmospheric corrections

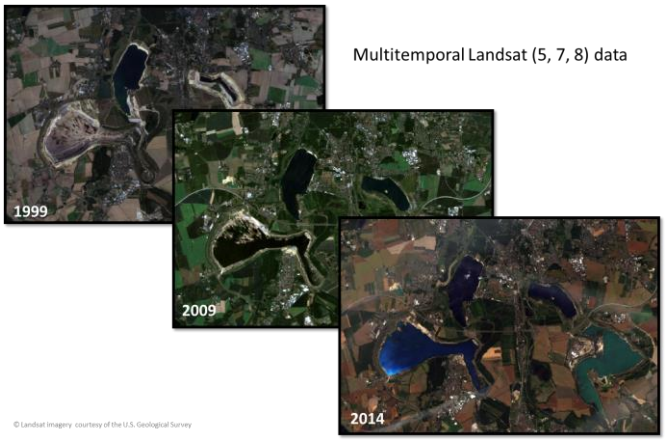


Path of rays in the atmosphere



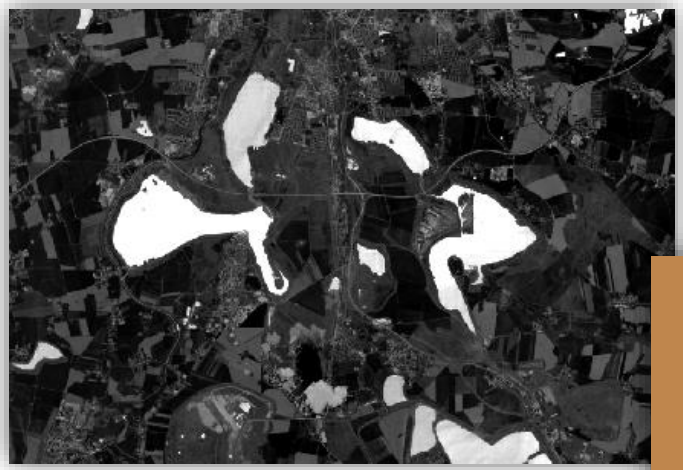
Atmospheric correction in the FLAASH module

Example: Assessing changes in post-mining landscapes

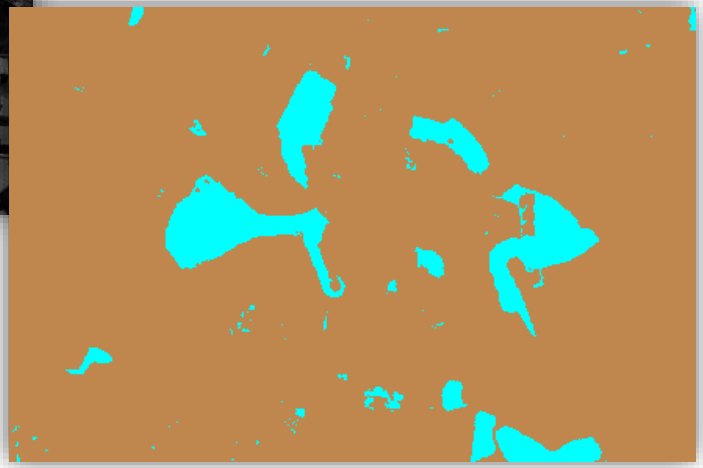


Multitemporal Landsat (5, 7, 8) data

Calculating different water indices



Extracting water areas by thresholding



Landsat imagery courtesy of the U.S. Geological Survey

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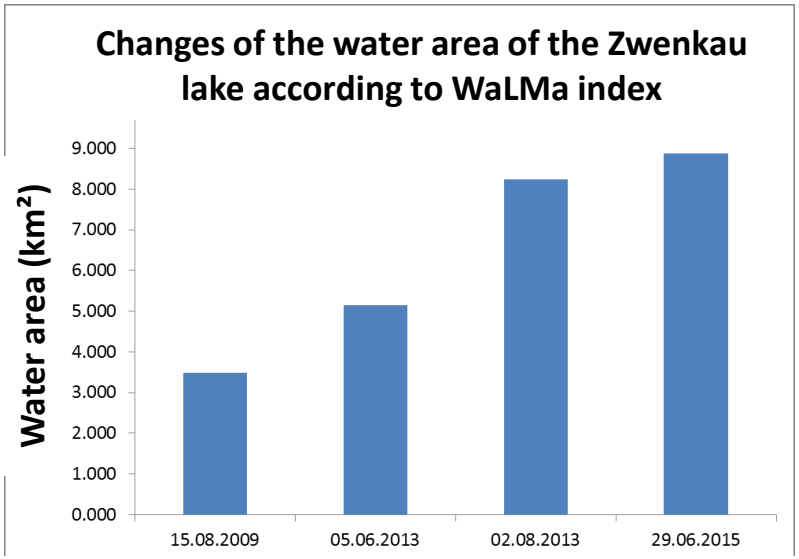
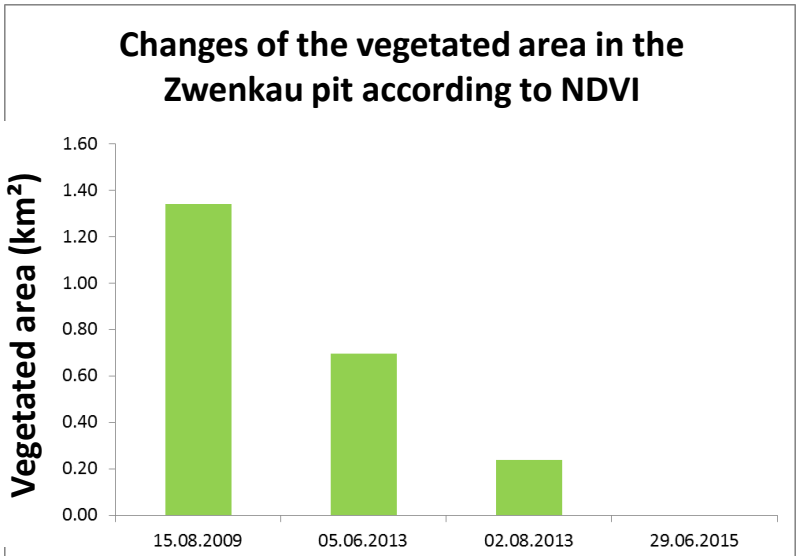
Example: Assessing changes in post-mining landscapes





Results:

- Specific water areas for each year and per water index
- Results are compared among each other with available reference information

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Example: Assessing vegetation phenology in Israel

(RapidEye image, Resa project no. 597)

- Heterogenous landscape
- Long Term Ecological Research Site
- ExpEER Ecosystem Research
- Different vegetation types with differing phenology

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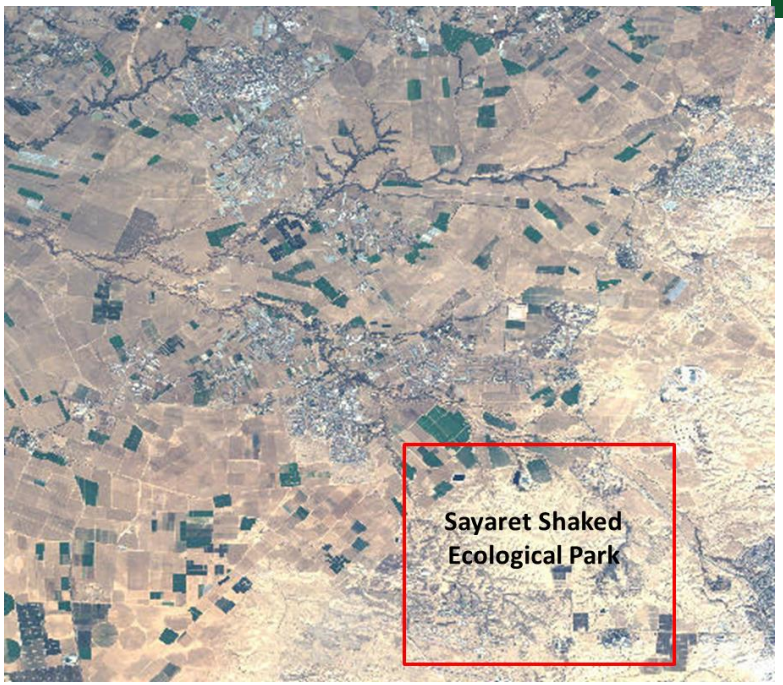
Example: Assessing vegetation phenology in Israel

- Annual & perennial vegetation, biolog. crusts
- Large variety and heterogenity in spatial distribution and cover density
- Sensitive response to precipitation

Aim:

Remote assessment of the phenology of the different vegetation units within the LTER site



(RapidEye image, Resa project no. 597, Photos: © RSC)

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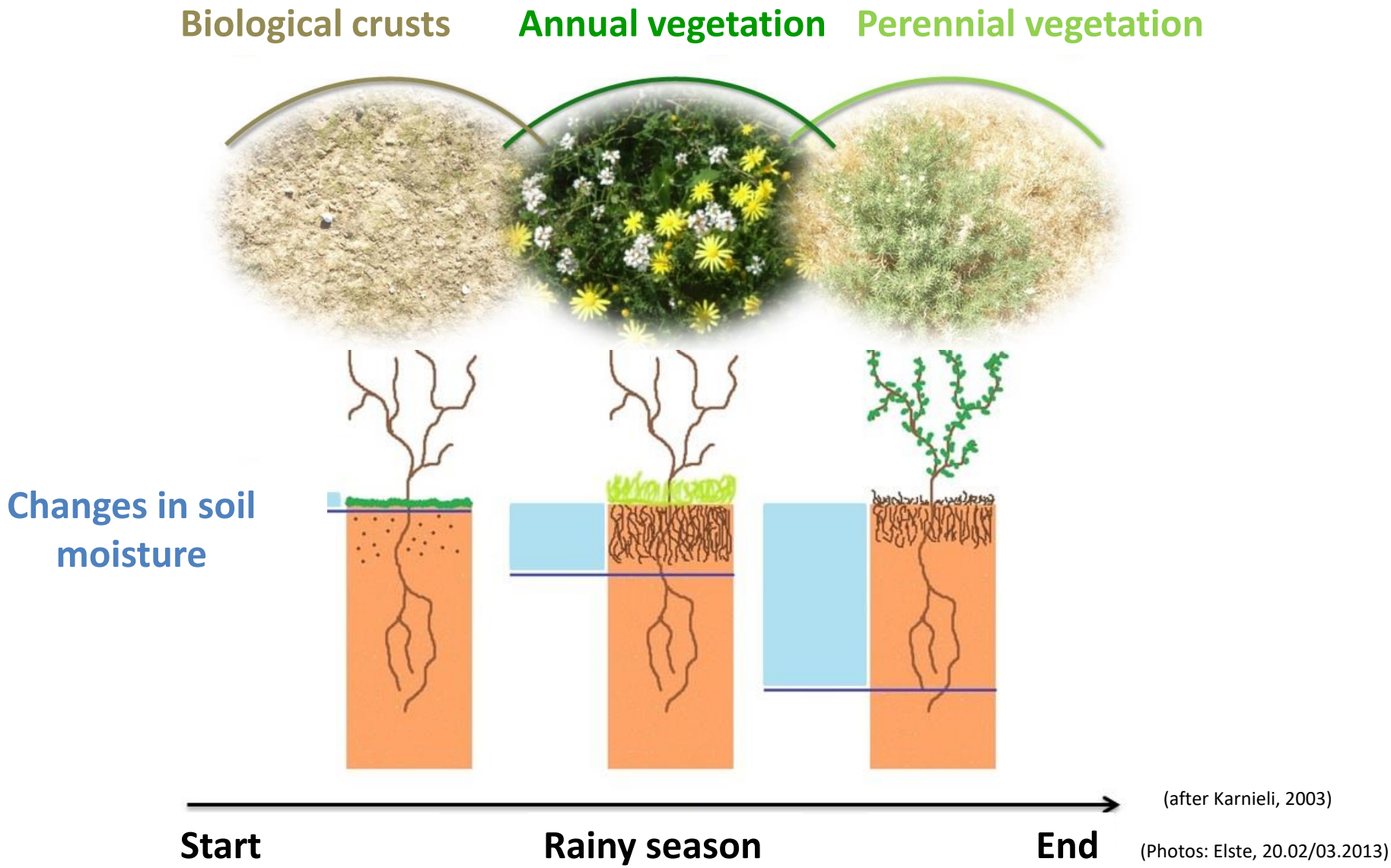
Example: Assessing vegetation phenology in Israel



Example: Assessing vegetation phenology in Israel

Used remote sensing data

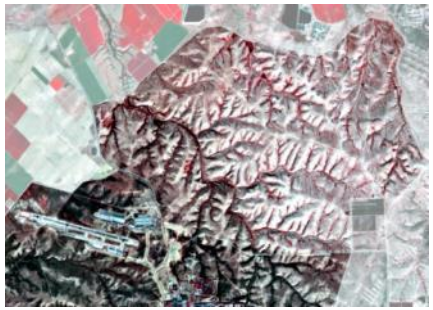
Rapid Eye data (spectral bands):

Blue	440-510 nm
Green	520-590 nm
Red	630-685 nm
Red Edge	690-730 nm
NIR	760-850 nm

http://www.dlr.de/rd/desktopdefault.aspx/tabid-2440/3586_read-5336/

RapidEye time-series in CIR (5/3/2), spatial resolution: 5 m

(01-Dec-2012)



(17-Jan-2013)

(26-Feb-2013)

(23-Apr-2013)

(RapidEye images, Resa project no. 597)

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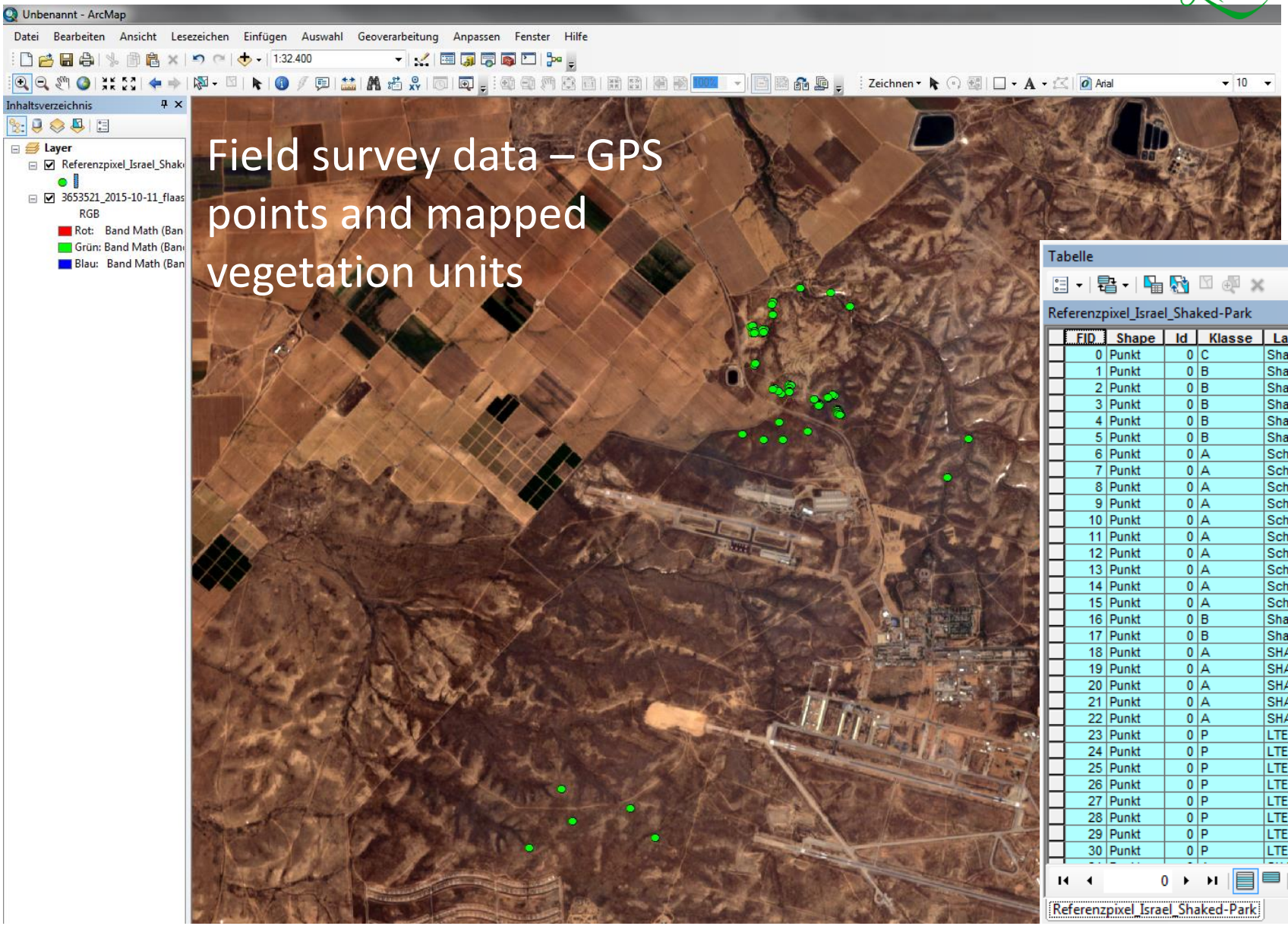
Example: Assessing vegetation phenology in Israel



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5	Punkt	0	B	Shaked	
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7	Punkt	0	A	Schaf	
8	Punkt	0	A	Schaf	
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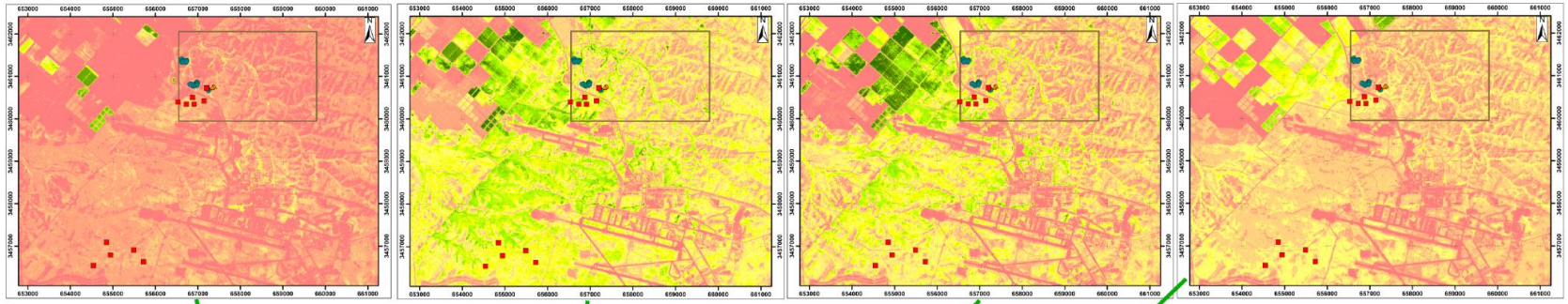
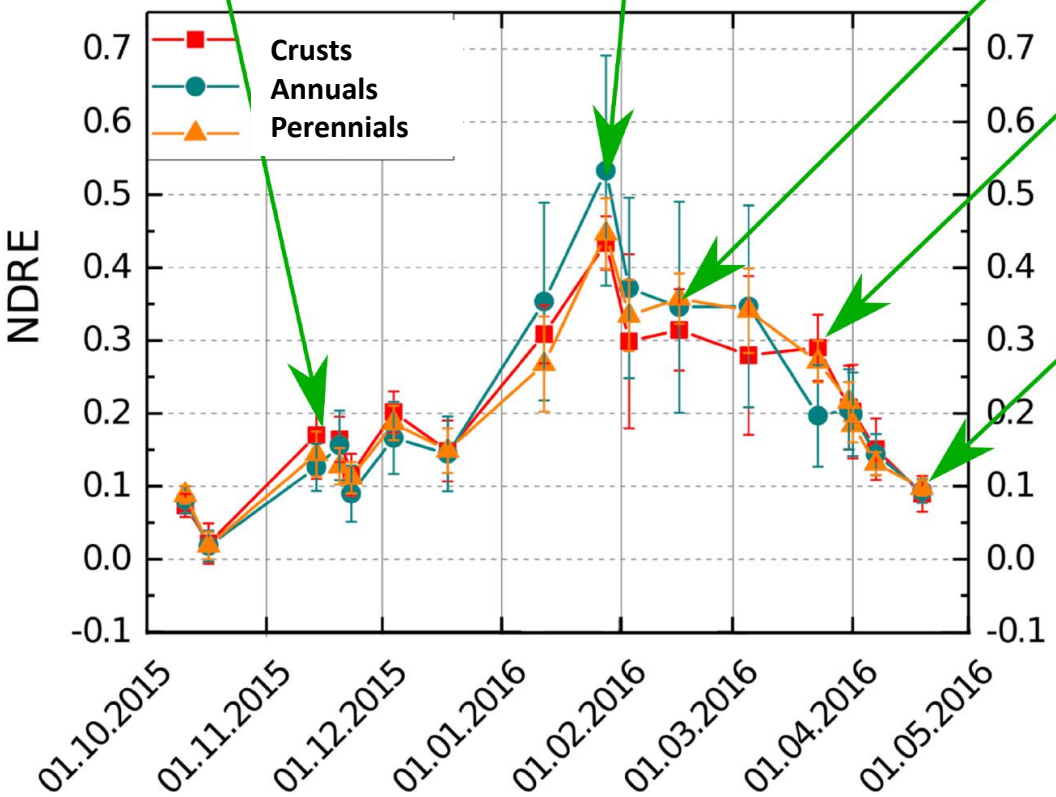
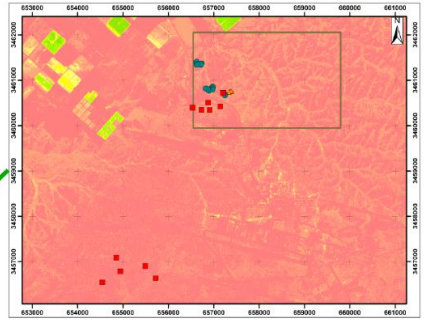
Example: Assessing vegetation phenology in Israel







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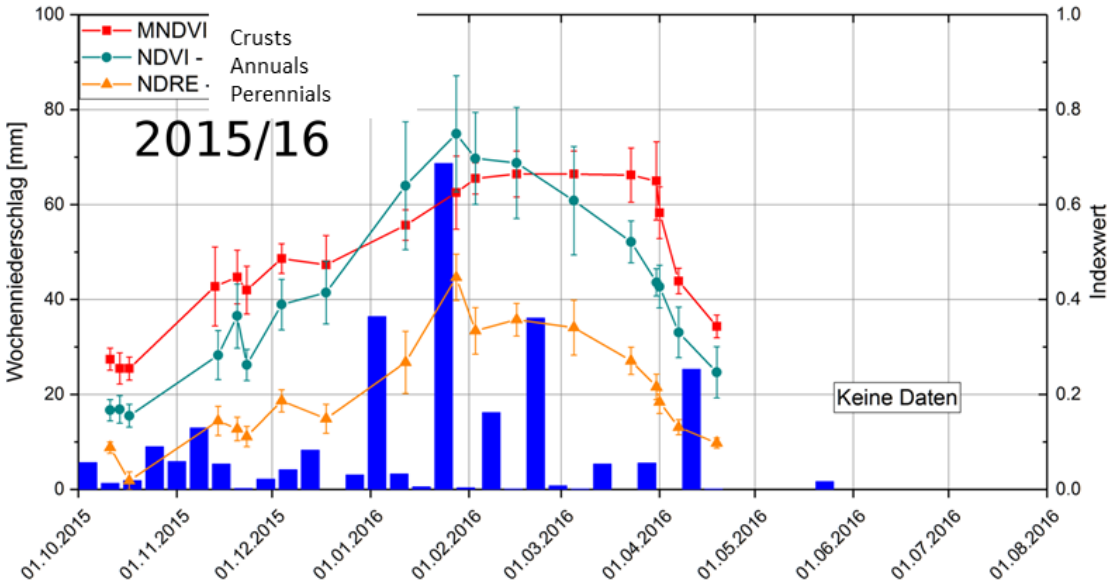
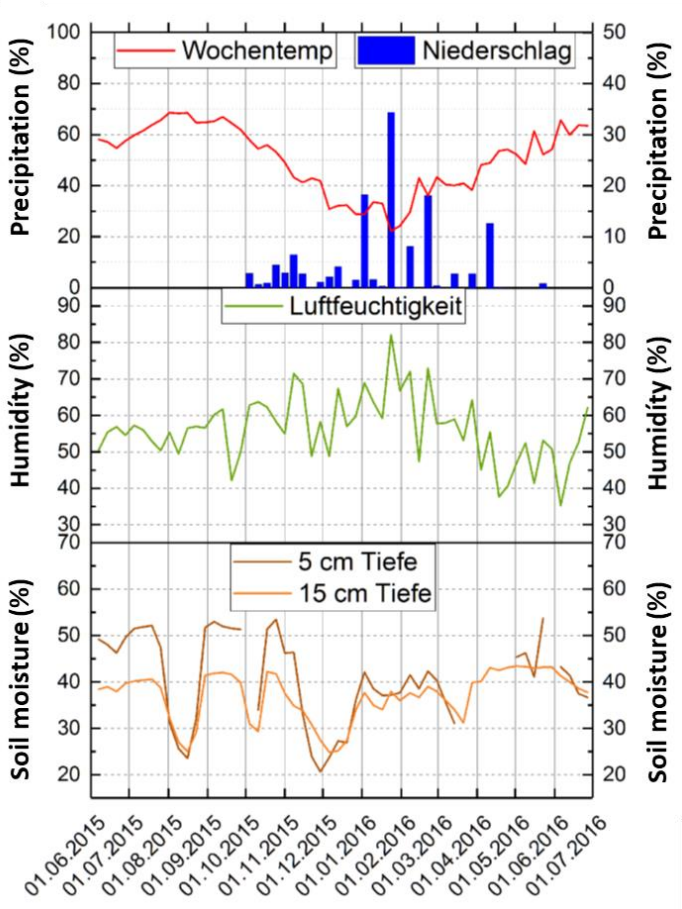
Example: Assessing vegetation phenology in Israel





Linking of phenological information and climatological data

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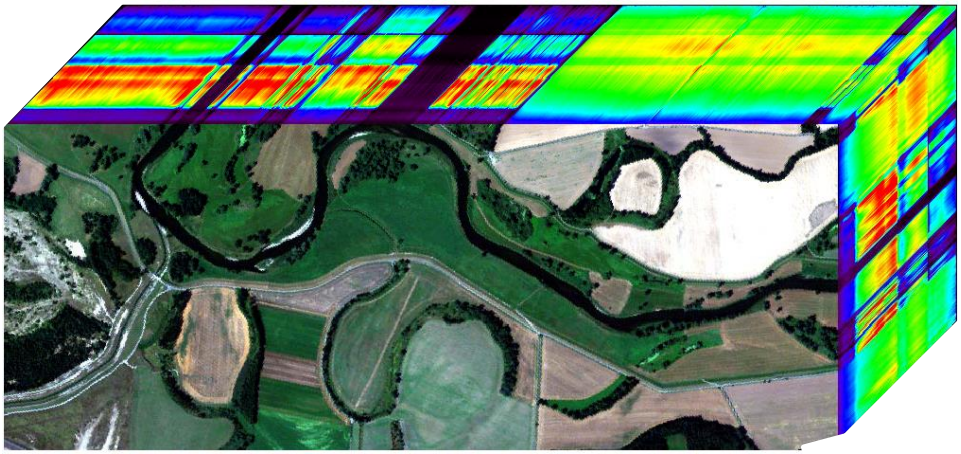
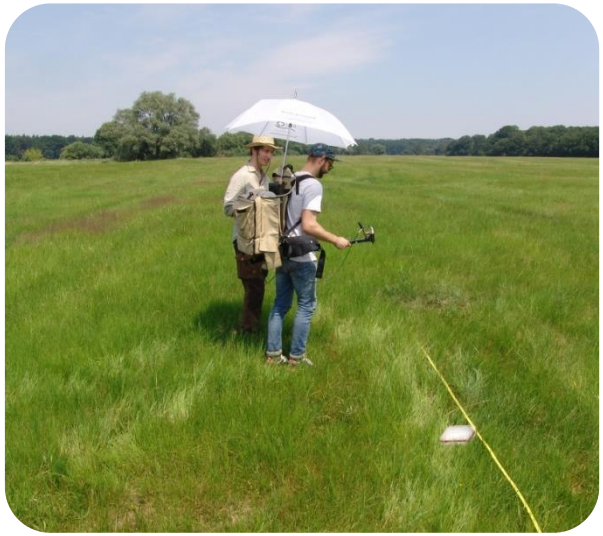
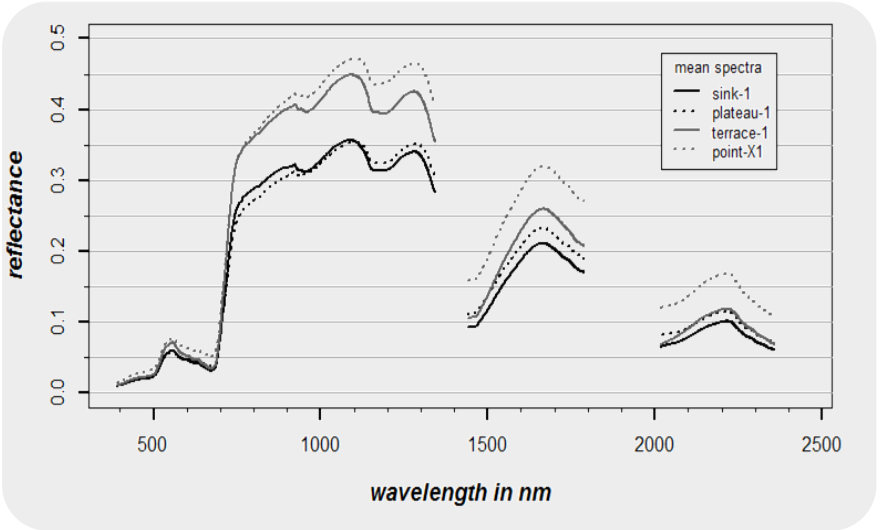
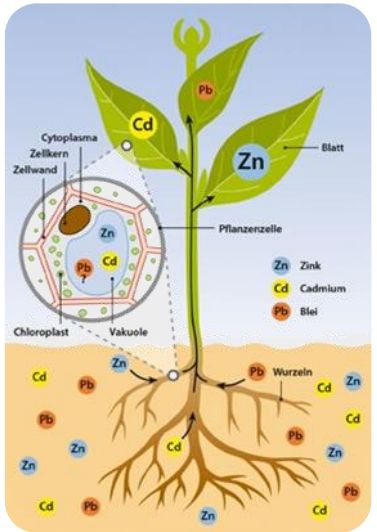
Example: Assessing vegetation stress in floodplains



Related to the project EnviMetal







Quelle: http://dradiowissen.de/beitrag/phytomining-mit-pflanzen-schwermetalle-gewinnen

Example: Assessing vegetation stress in floodplains

Background:

- Increase in frequency and intensity of flood events
- Enrichment of heavy metals (HM) in flood areas

Aim:

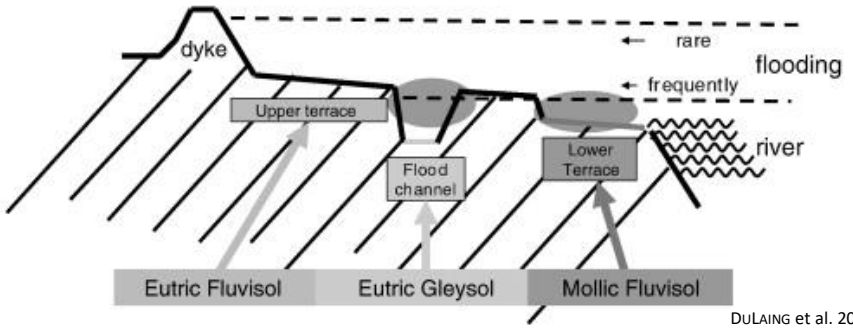
- Spatial monitoring of floodplain ecosystems
- Spatial assessing vegetation stress and potential ecotoxicological effects using FE methods

Challenges:

- Various influencing factors (vegetation, soil, terrain...)
- HM accumulation is element & plant-specific
- seasonal effects, spatial & temporal dynamics
- Natural vs HM-induced vevegtation stress

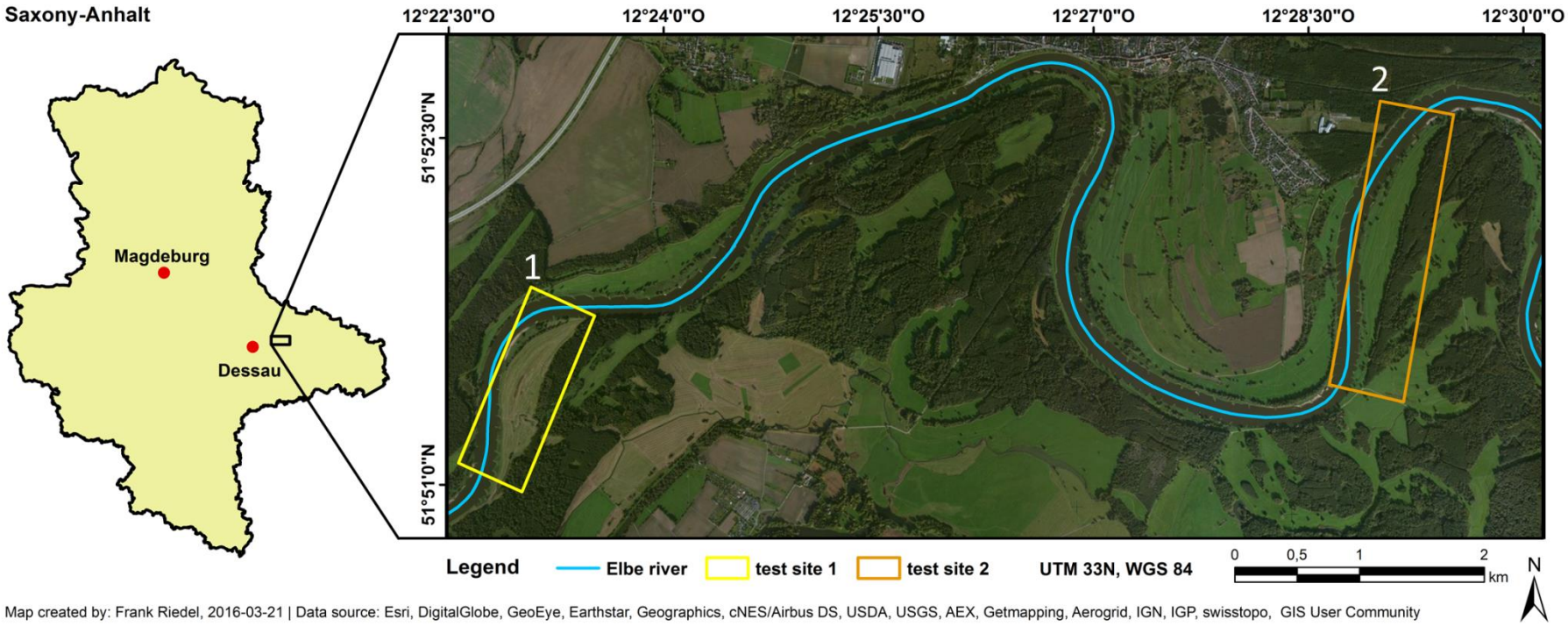
BMU & BFN 2009:27)

Relief in floodplains



DuLaing et al. 2009

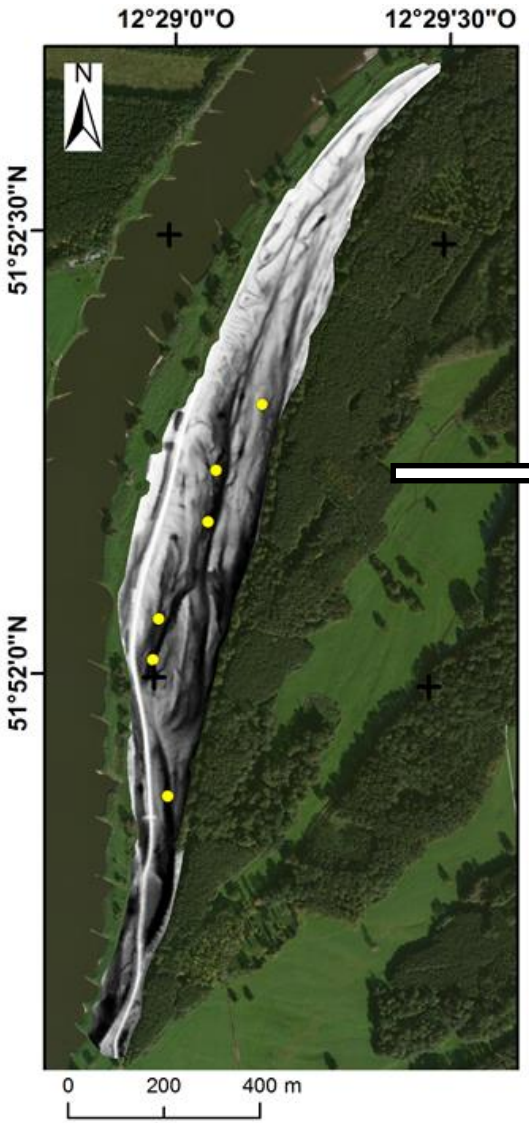
Example: Assessing vegetation stress in floodplains

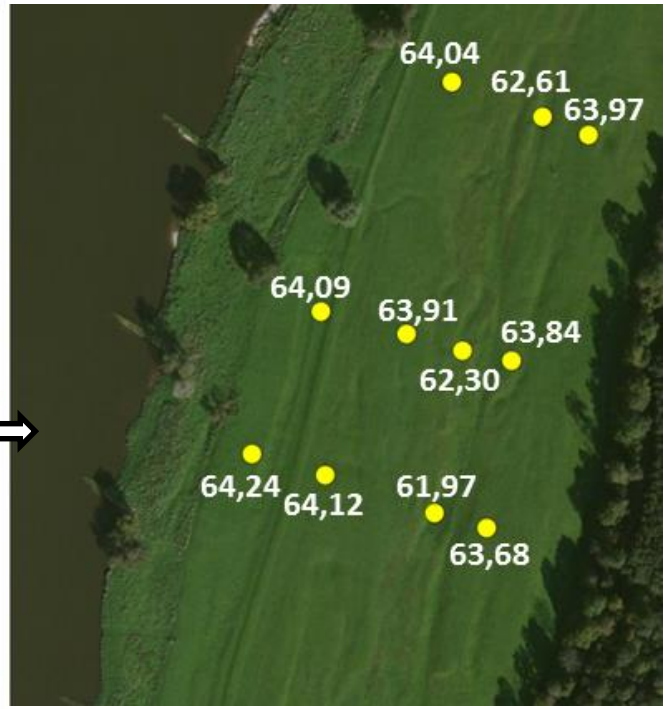


Aims in the course:

- Analysis of the relationship between vegetation spectral properties and plant parameters (growth heights, SPAD values, chemical soil and vegetation values)
- Analysis of the relationship between vegetation indices and fine relief

Example: Assessing vegetation stress in floodplains





DTM & DOP: © LVermGeo Sachsen-Anhalt

Measurement points

- Trimble AgGPS® RTK Base 450
- X, Y, Z coordinates
- Data format: shape file

Field spectra

- Measured along cross sections in representative morphological units
- ASD FieldSpec Pro FR (350-2500 nm)

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Example: Assessing vegetation stress in floodplains

SPAD-values

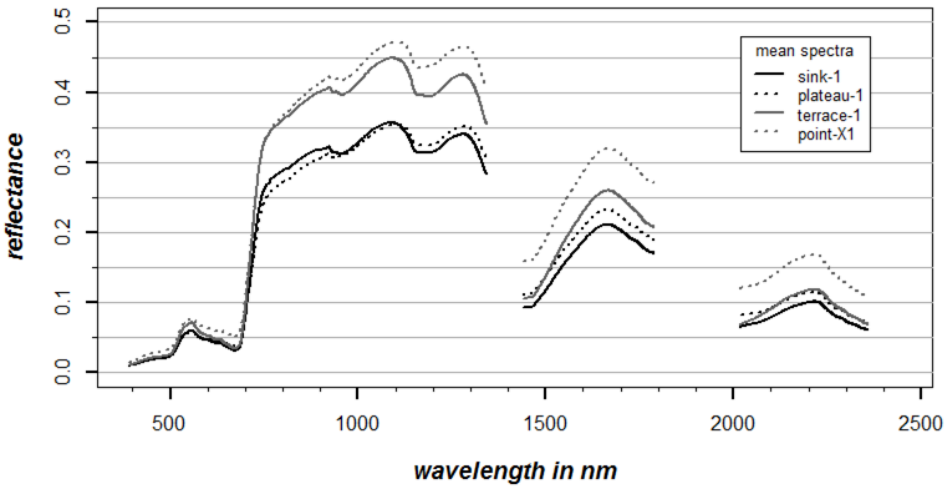
Vegetation heights

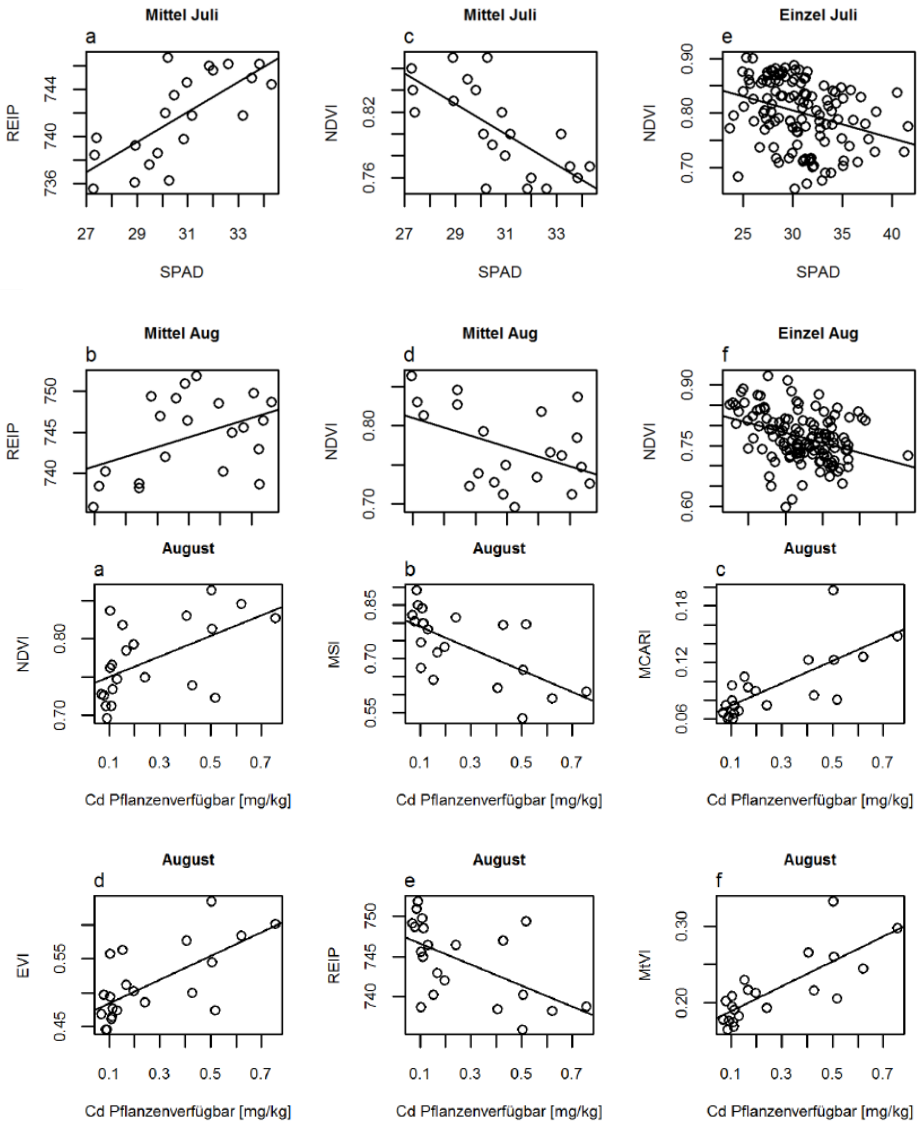
Chemical properties

	Concentration (mg kg^{-1})				
	Cu	Pb	Zn	Cd	Ni
Ø Sinks	68.19	110.64	253.00	1.54	37.24
Ø Terraces	53.33	77.40	211.77	1.16	36.71
Ø Plateaus	52.81	80.35	227.43	1.40	35.90
Ø Total	58.11	89.46	230.73	1.37	36.62
Min	40.66	60.83	165.43	0.79	31.00
Max	109.00	138.83	432.77	3.29	45.33

Photos © RSC

Example: Assessing vegetation stress in floodplains





Results: Correlations between vegetation spectral data, SPAD and HM values.

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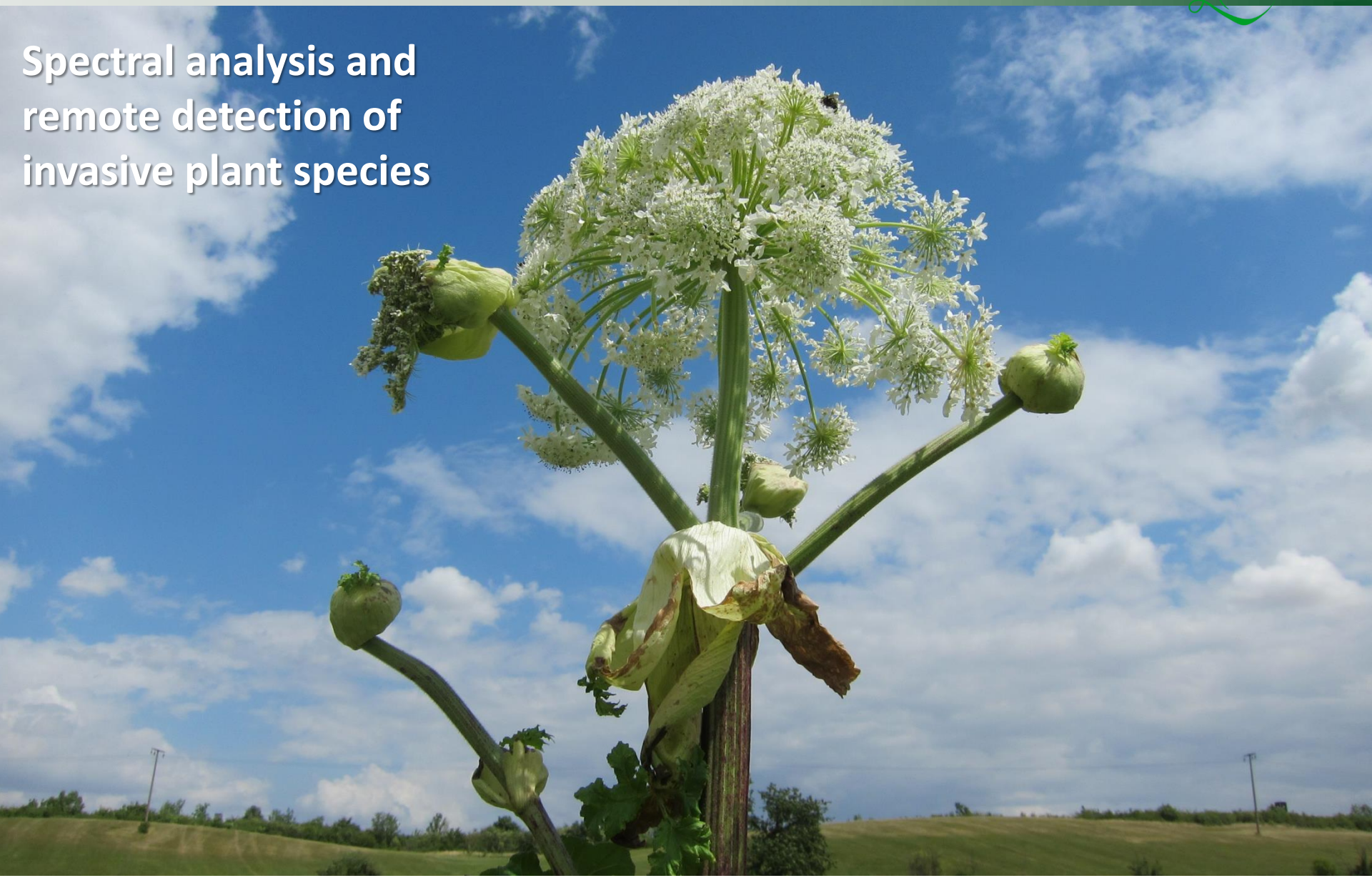
Example: Spectral analysis of invasive plant species



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Example: Spectral analysis of invasive plant species

Photos: Meißner 2014/2015, Götze 2014

***Heracleum mantegazzianum* (giant hogweed):**

- Short-lived shrub, height of growth: 2 - 5 m
- Photodermatitis on contact and sunlight
- Displacement of other species
- Increased risk of erosion at water margins
- Treatment is time-consuming and costly and requires detailed knowledge of occurrences

RS methods offer great potential for detecting giant hogweed!

- Only few studies available
- Basic knowledge about spectral properties is required
- Knowledge of mixed spectral signatures is crucial

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Example: Spectral analysis of invasive plant species

Aims in the course:

- Extension of the knowledge base of the spectral properties of the GH
- Extension of the knowledge by spectral GH mixed signatures
- better knowledge for GH detection using remote sensing data

- Teaching competencies in qualitative and quantitative spectral analysis
- Transfer of know-how in spectrometric measurements (theory & practice)
- Training in LAI, SPAD, GNSS measurements

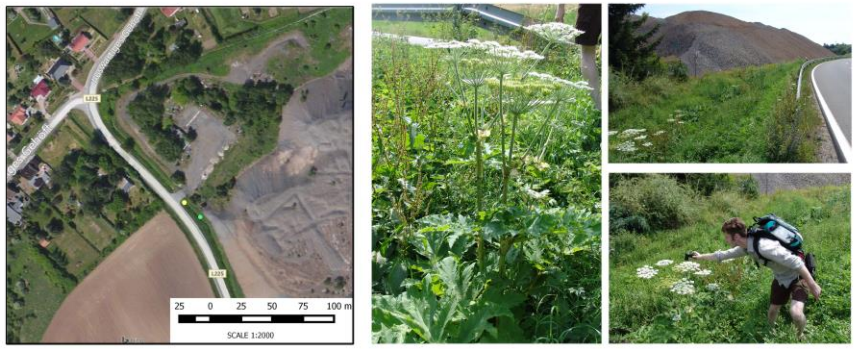
Example: Spectral analysis of invasive plant species

Utilised data:

- Field spectra
- Field photos
- Field mapping data
- GPS coordinates

- Several RapidEye images, March – September 2014

Test site - Wimmelburg (Otto-Dump)



Spectral plots of the different parts of giant hogweed

© RSC

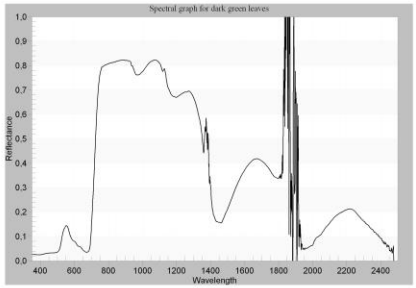
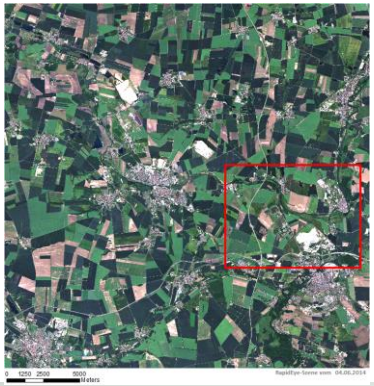


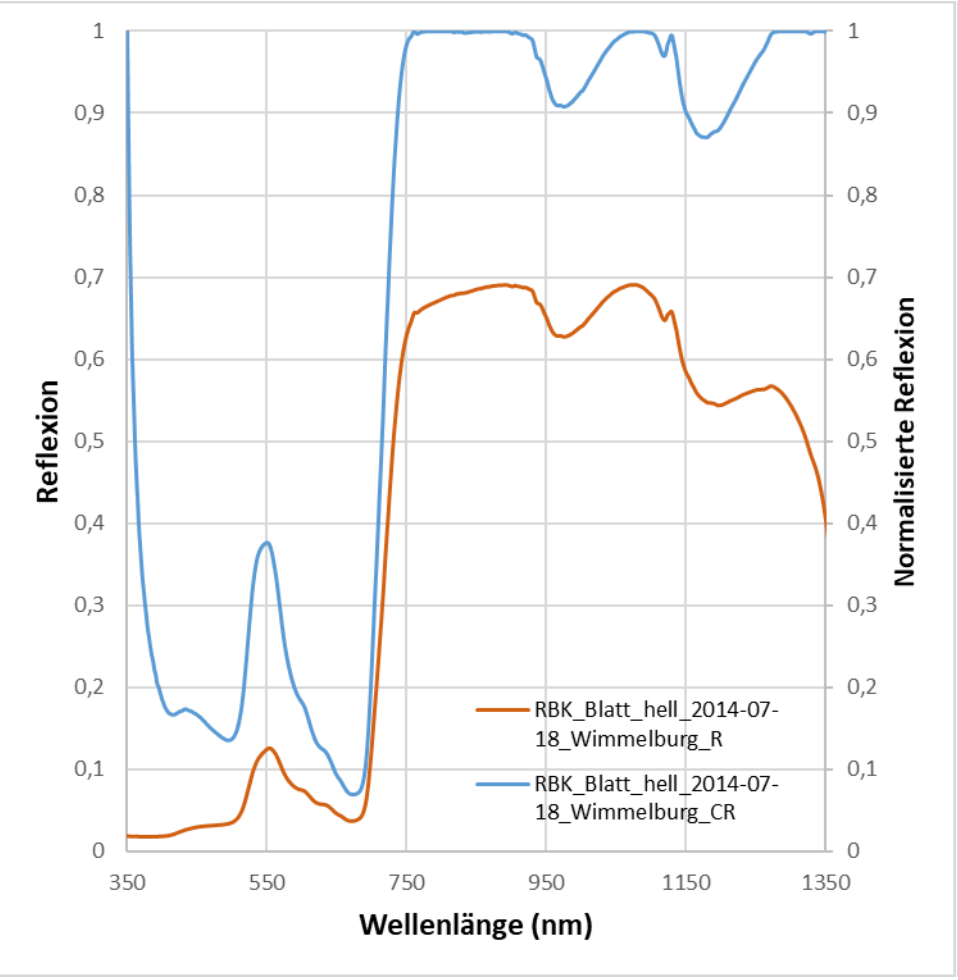
Fig 5. Spectral graph for the dark green leaves.

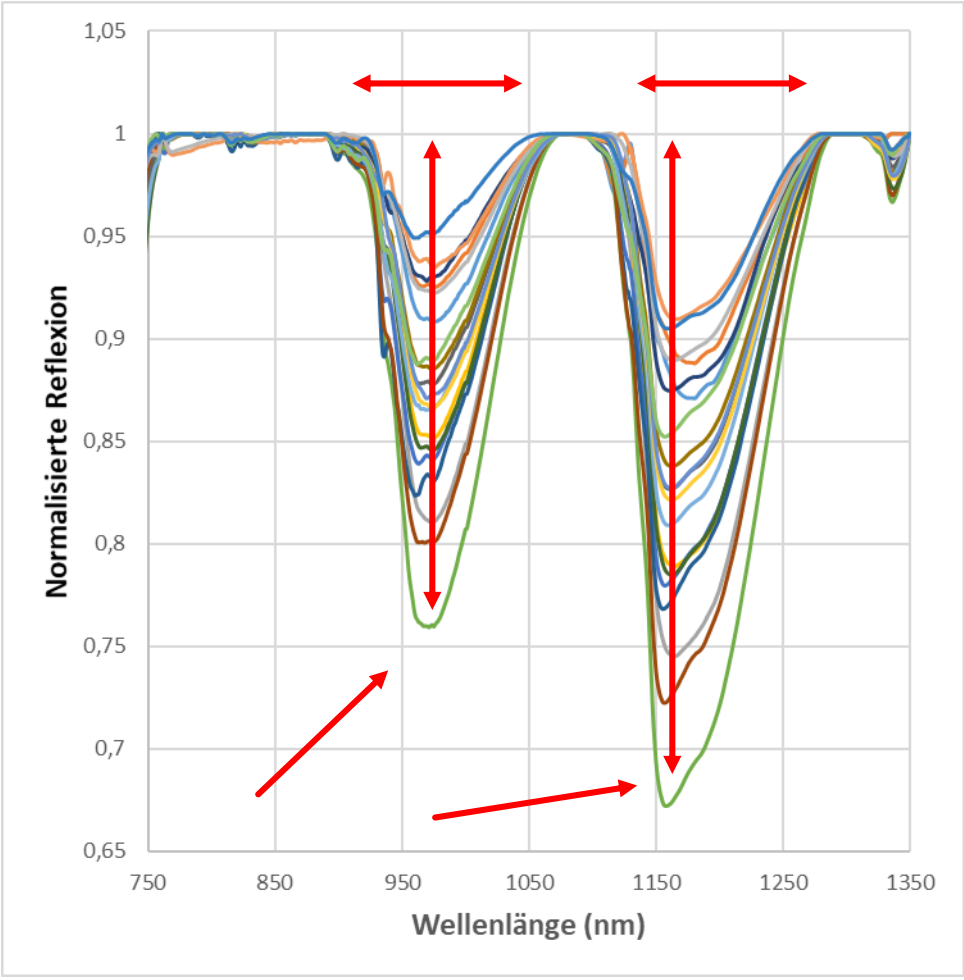
© RSC

http://www.dlr.de/rd/desktopdefault.aspx/tabid-2440/3586_read-5336/



Example: Spectral analysis of invasive plant species





Advanced data analysis: Quantification and parameterisation of spectral features (e.g. positions and depths of absorptions) followed by statistical analyses

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Example: Spectral analysis of invasive plant species

Analysis of RapidEye data for spatio-temporal mapping GH occurences

Dates of RapidEye imagery and applicability of different detection methods

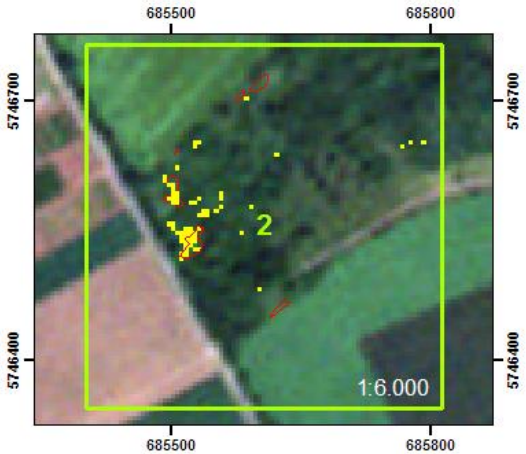
	10.03.	27.03.	16.04.	04.06.	04.07.	17.07.	06.09.
Multiband Thresholding	-	-	x	x	x	(x)	-
VIO (Permutation)	-	-	-	x	-	-	-
Matched Filtering	-	-	-	x	-	-	-

Multiband thresholding

EM_{100} 04.06.

Vegetation index optimising

EM_{NIR} 04.06.



Matched filtering

EM_{100} 04.06.

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Advanced geological & mineralogical Remote Sensing

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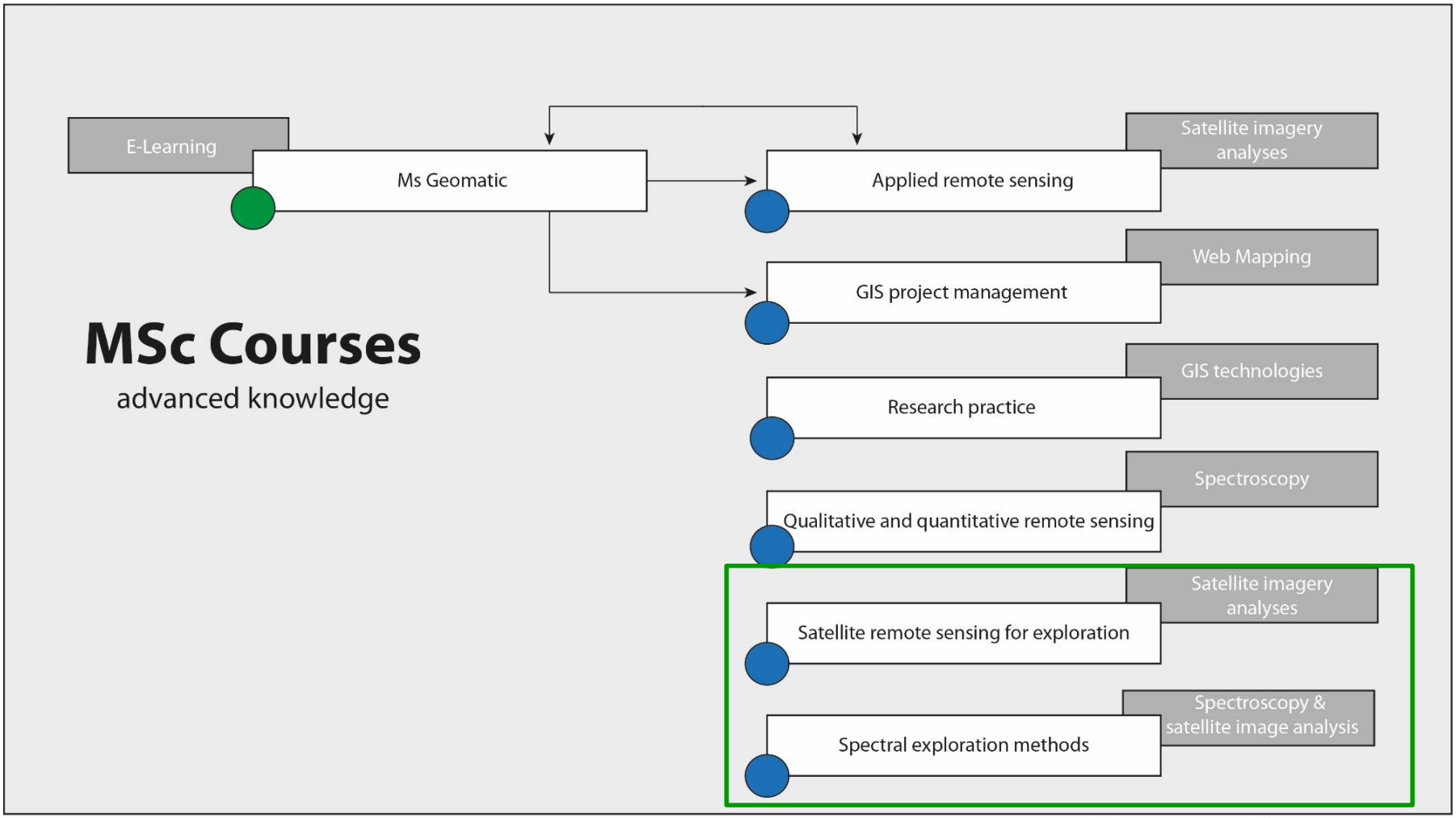
HALLE-WITTENBERG



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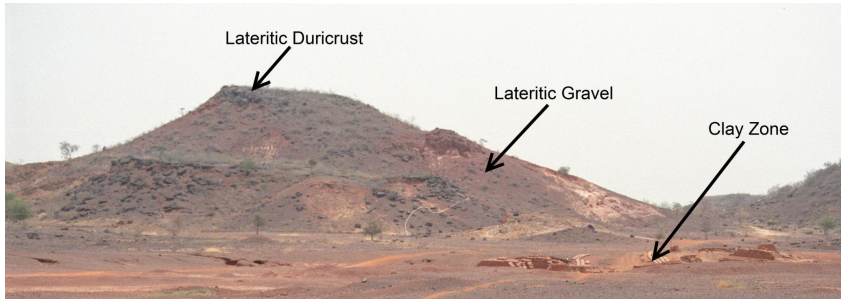
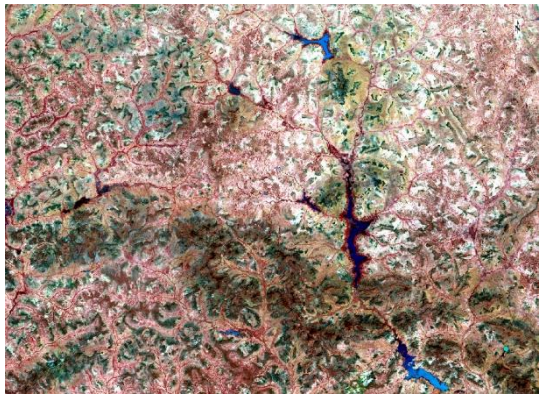
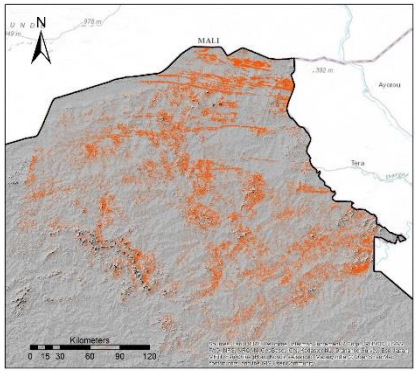
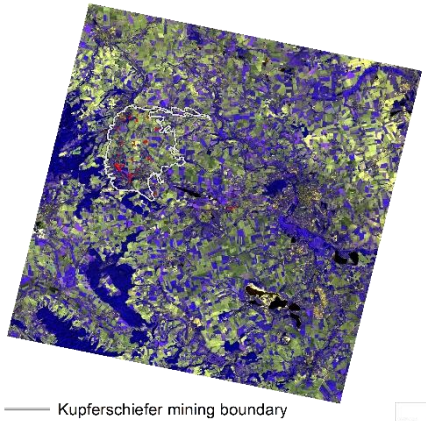
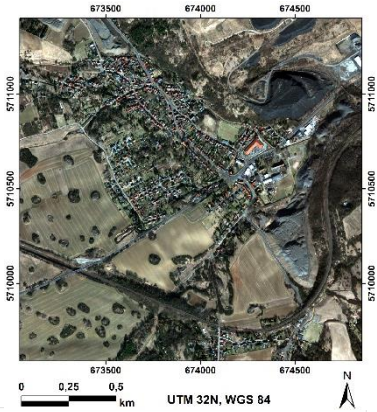
Advanced geological & mineralogical Remote Sensing





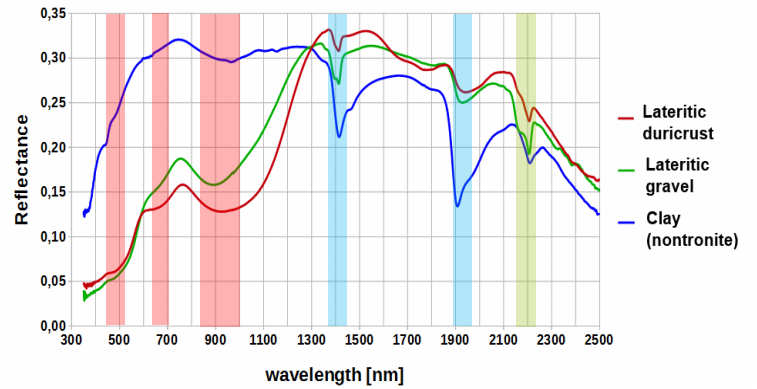


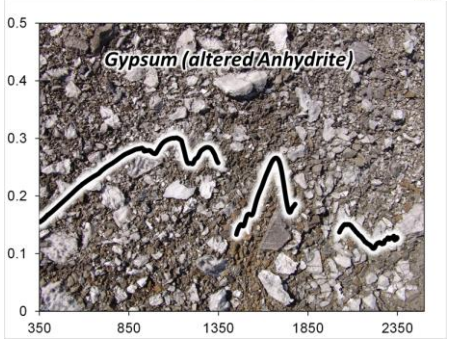




Kupferschiefer mining boundary

Dumps & heaps





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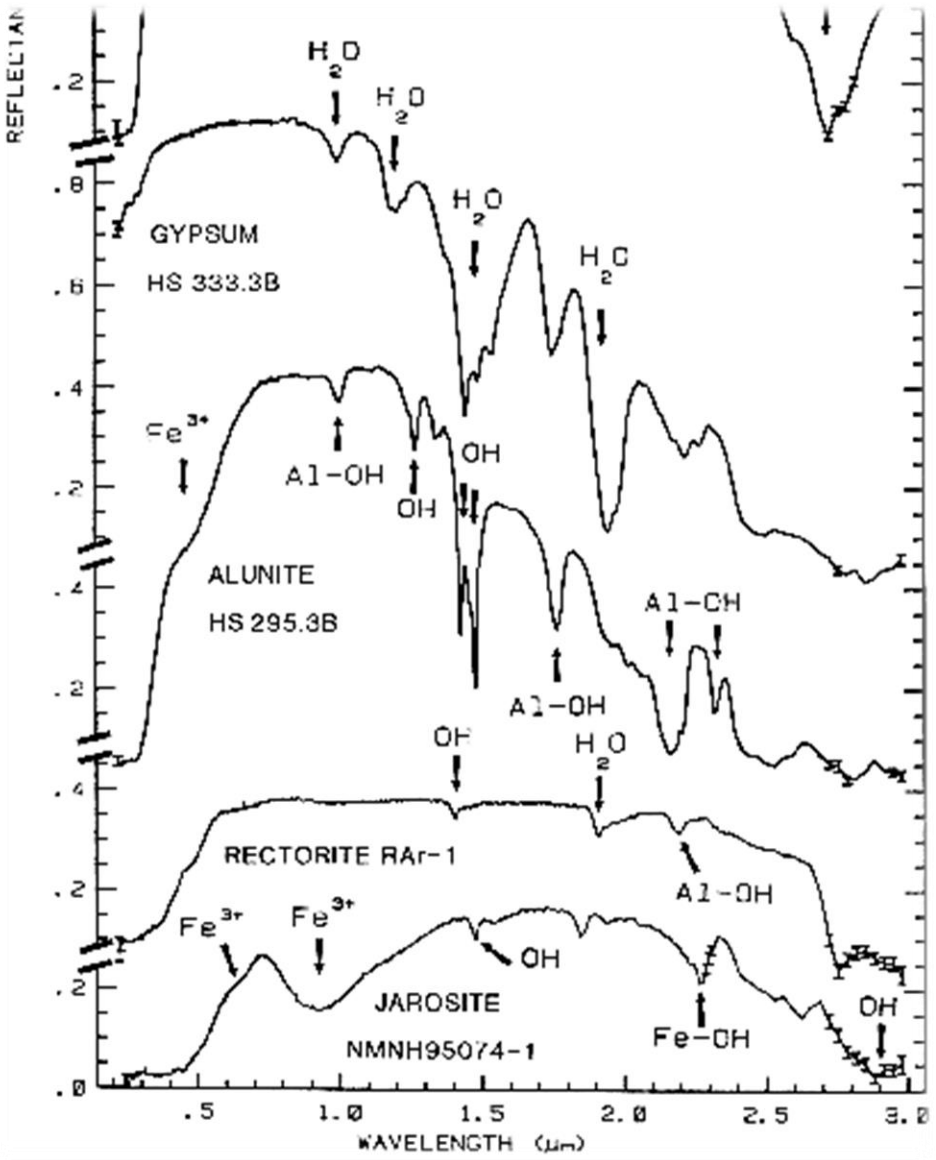
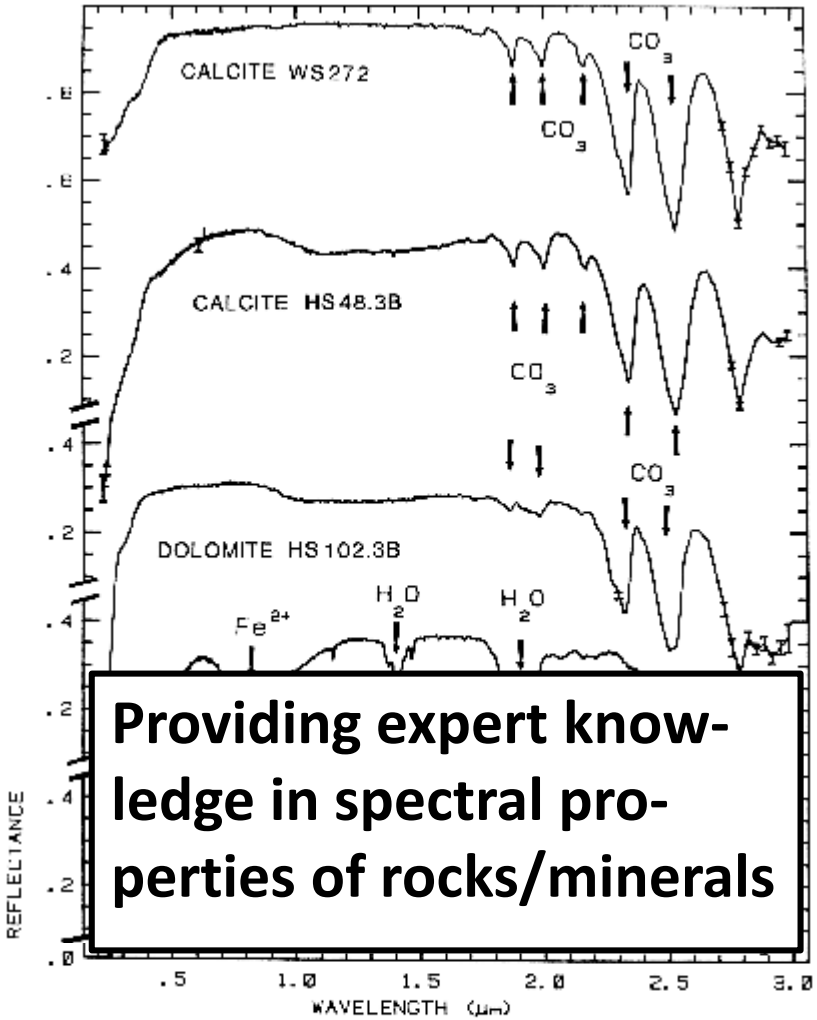
Spectral exploration methods

From: Clark, R. N., Chapter 1: Spectroscopy of Rocks and Minerals, and Principles of Spectroscopy, in *Manual of Remote Sensing, Volume 3, Remote Sensing for the Earth Sciences*, (A.N. Rencz, ed.) John Wiley and Sons, New York, p 3- 58, 1999.





Providing expert know-ledge in spectral pro-perties of rocks/minerals

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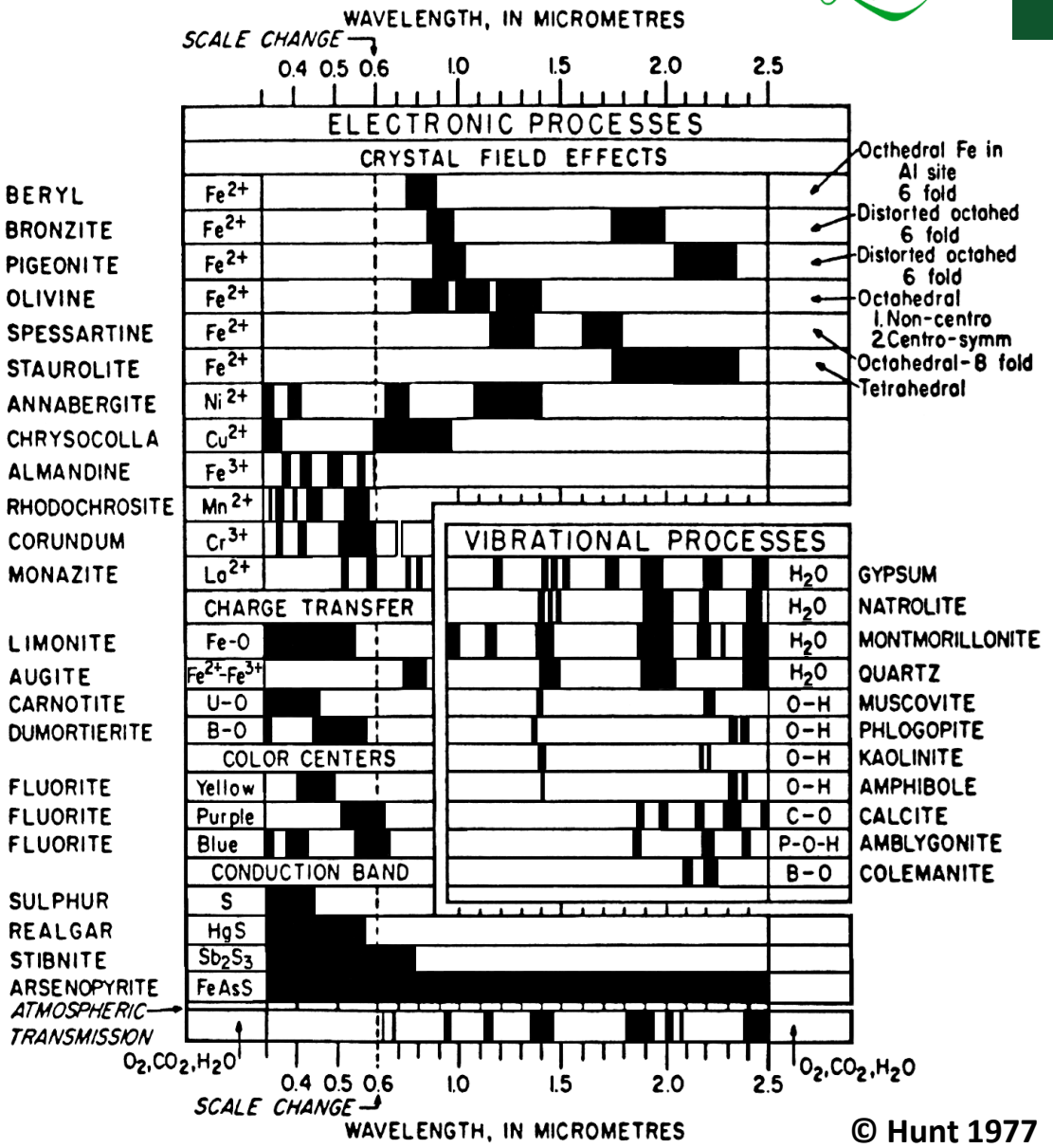
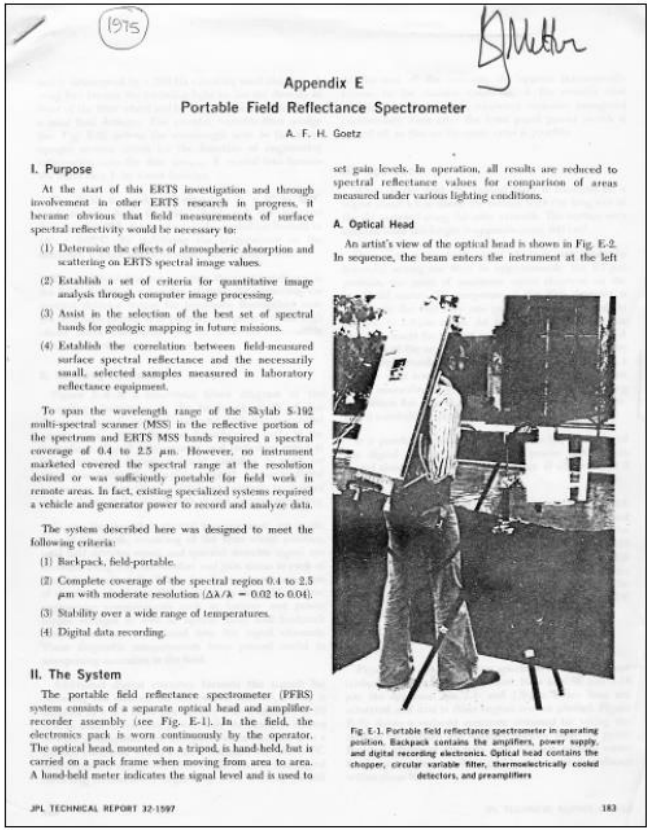
Spectral exploration methods

Providing in-depth know-how on causes for mineral absorptions



© Hunt 1977

Spectral exploration methods



1975

Appendix E

Portable Field Reflectance Spectrometer

A. F. H. Goetz

I. Purpose

At the start of this ERTS investigation and through involvement in other ERTS research in progress, it became obvious that field measurements of surface spectral reflectivity would be necessary to:

(1) Determine the effects of atmospheric absorption and scattering on ERTS spectral image values.

(2) Establish a set of criteria for quantitative image analysis through computer image processing.

(3) Assist in the selection of the best set of spectral bands for geologic mapping in future missions.

(4) Establish the correlation between field-measured surface spectral reflectance and the necessarily small, selected samples measured in laboratory reflectance equipment.

To span the wavelength range of the Skylab S-192 multi-spectral scanner (MSS) in the reflective portion of the spectrum and ERTS MSS bands required a spectral coverage of 0.4 to 2.5 μm. However, no instrument marketed covered the spectral range at the resolution desired or was sufficiently portable for field work in remote areas. In fact, existing specialized systems required a vehicle and generator power to record and analyze data.

The system described here was designed to meet the following criteria:

(1) Backpack, field-portable.

(2) Complete coverage of the spectral region 0.4 to 2.5 μm with moderate resolution ($\Delta\lambda/\lambda$ = 0.02 to 0.04).

(3) Stability over a wide range of temperatures.

(4) Digital data recording.

II. The System

The portable field reflectance spectrometer (PFRS) system consists of a separate optical head and amplifier-recorder assembly (see Fig. E-1). In the field, the electronics pack is worn continuously by the operator. The optical head, mounted on a tripod, is hand-held, but is carried on a pack frame when moving from area to area. A hand-held meter indicates the signal level and is used to set gain levels. In operation, all results are reduced to spectral reflectance values for comparison of areas measured under various lighting conditions.

A. Optical Head

An artist's view of the optical head is shown in Fig. E-2. In sequence, the beam enters the instrument at the left

Fig. E-1. Portable field reflectance spectrometer in operating position. Backpack contains the amplifiers, power supply, and digital recording electronics. Optical head contains the chopper, circular variable filter, thermoelectrically cooled detectors, and preamplifiers

JPL TECHNICAL REPORT 32-1597

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http://www.grs.wur.nl/UK/Workshops/Environmental+Applications+Imaging+Spectroscopy

Providing information on the historical development of reflectance spectroscopy & on platforms and the manifold measurement set-ups

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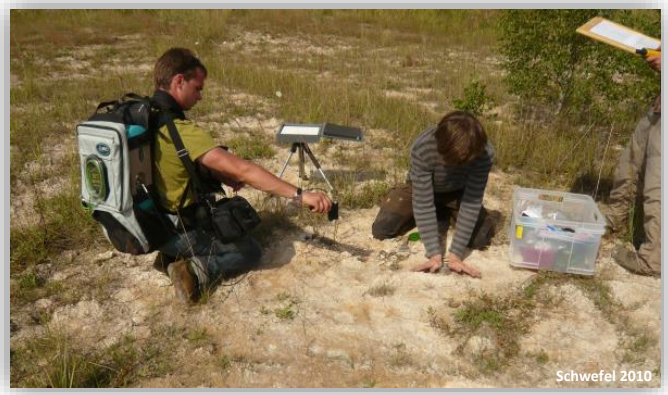
Spectral exploration methods

ASD FieldSPec Pro FR and operator notebook[1)]



Spectroscopic field measurements and field sampling during summer 2010. The ASD FieldSpec is placed in a backpack.

Set up for spectroscopic lab measure-ments using an artificial light source.

Providing training in operating the department´s instruments and accessories
Providing good-practice in how to conduct spectral measurements properly

Leaf Clip

PDA

Contact Probe

Figures: ASD FieldSpec® Dual RS³ Operation Manual 2010.; http://www.spectralevolution.com/sitebuilder/images/Trigger_leaf_clip4-178x204.png,http://www.spectralevolution.com/sitebuilder/images/Getac2-107x210.png, http://www.spectralevolution.com/sitebuilder/images/Desktop_contact_probe-201x162.jpg

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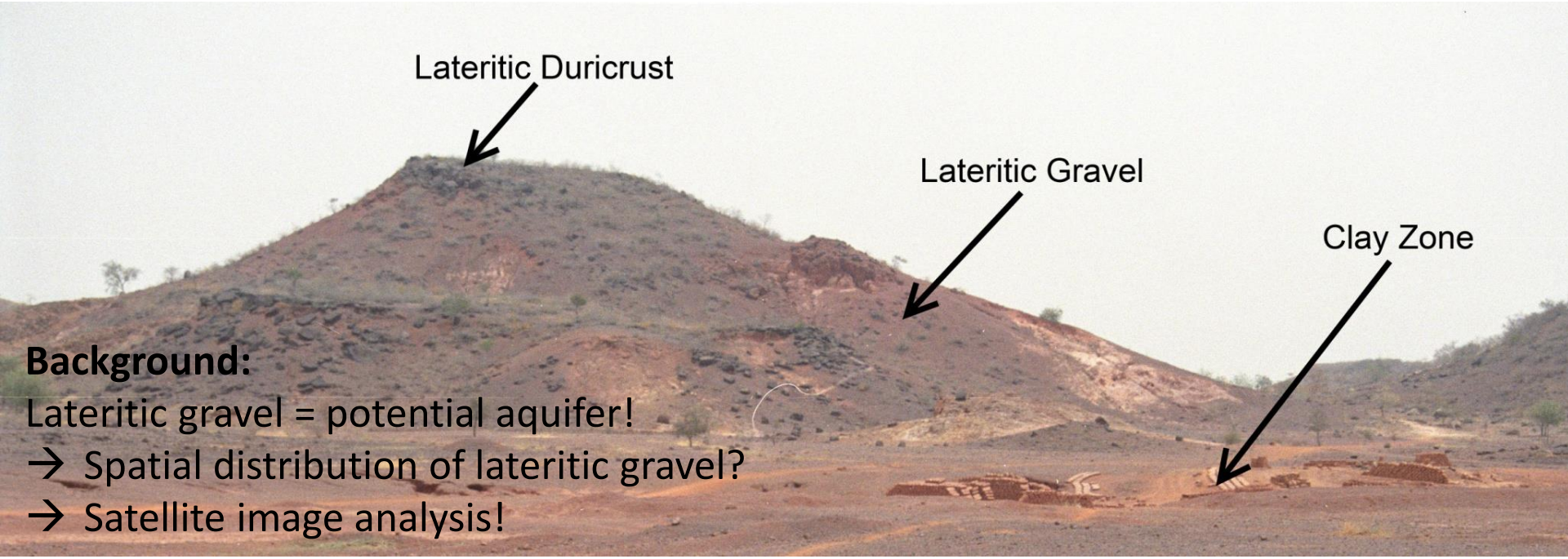
Example: Advanced geological RS for laterite mapping

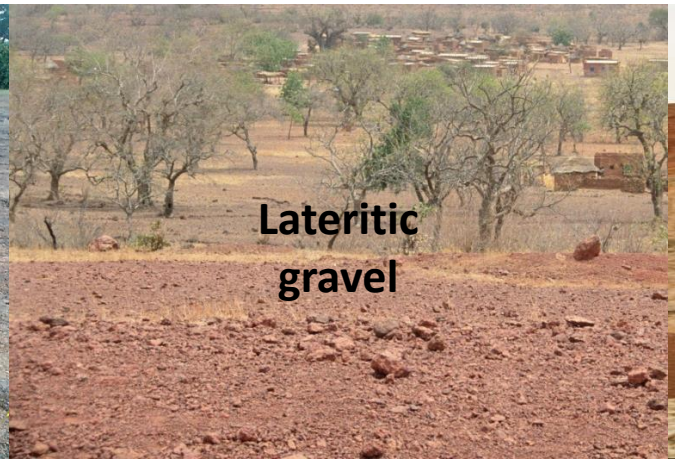


Background:

Lateritic gravel = potential aquifer!

→ Spatial distribution of lateritic gravel?

→ Satellite image analysis!



Photos: © Gläßer

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Example: Advanced geological RS for laterite mapping

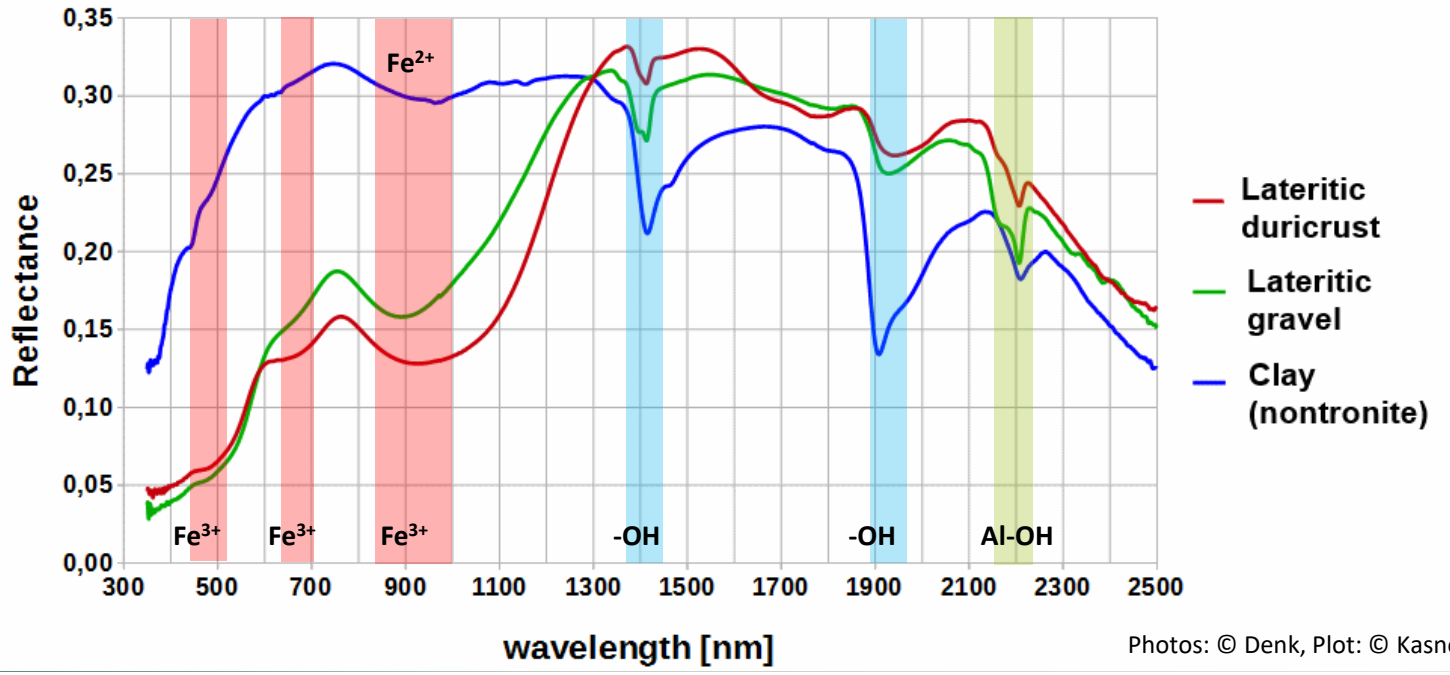
Measuring rock samples in the lab for assessing their spectral properties

Lateritic duricrust

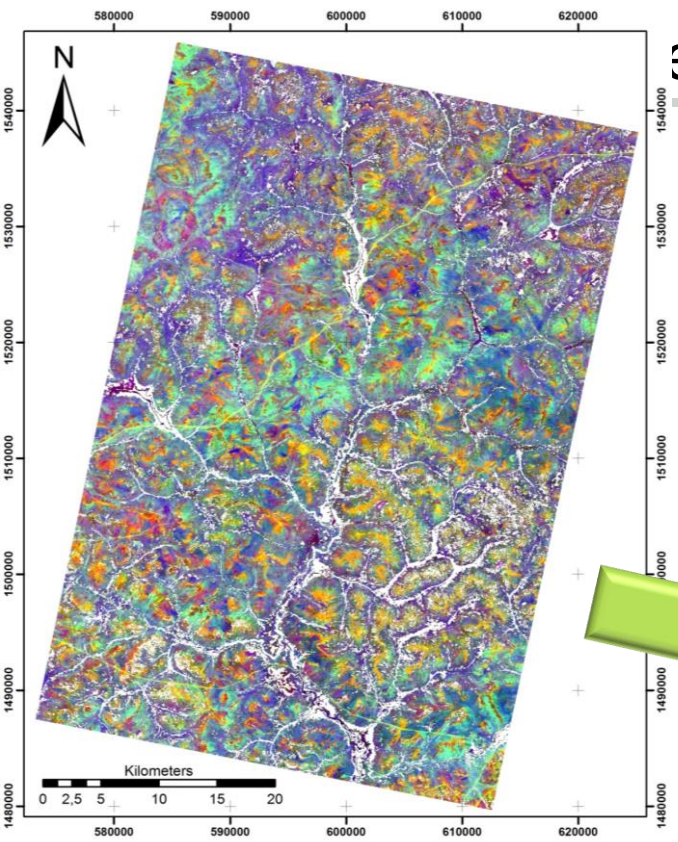
Lateritic gravel

Clay zone sample

Target Class	Mineral Composition
Lateritic duricrust	Hematite, Quartz, Kaolinite, Boehmite, Gibbsite
Lateritic gravel	Hematite, Quartz, Kaolinite, Maghemite, Lepidocrocite
Clay zone	Quartz, Nontronite, Antigorite, Epidote, Muscovite, Diopside, Albite



Photos: © Denk, Plot: © Kasner



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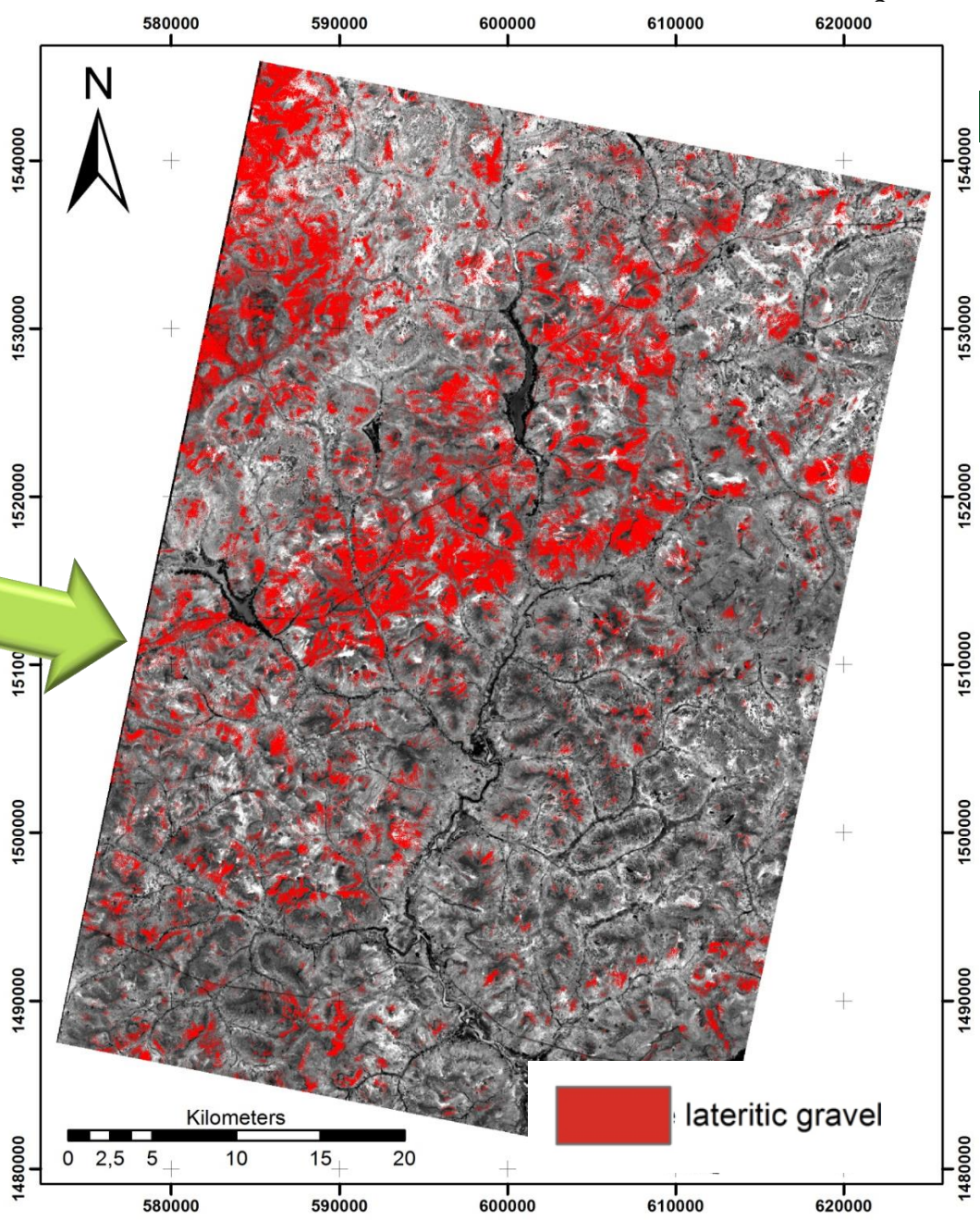

- **Classification** of colour composites

➢ Extraction of lateritic gravel and valley fillings

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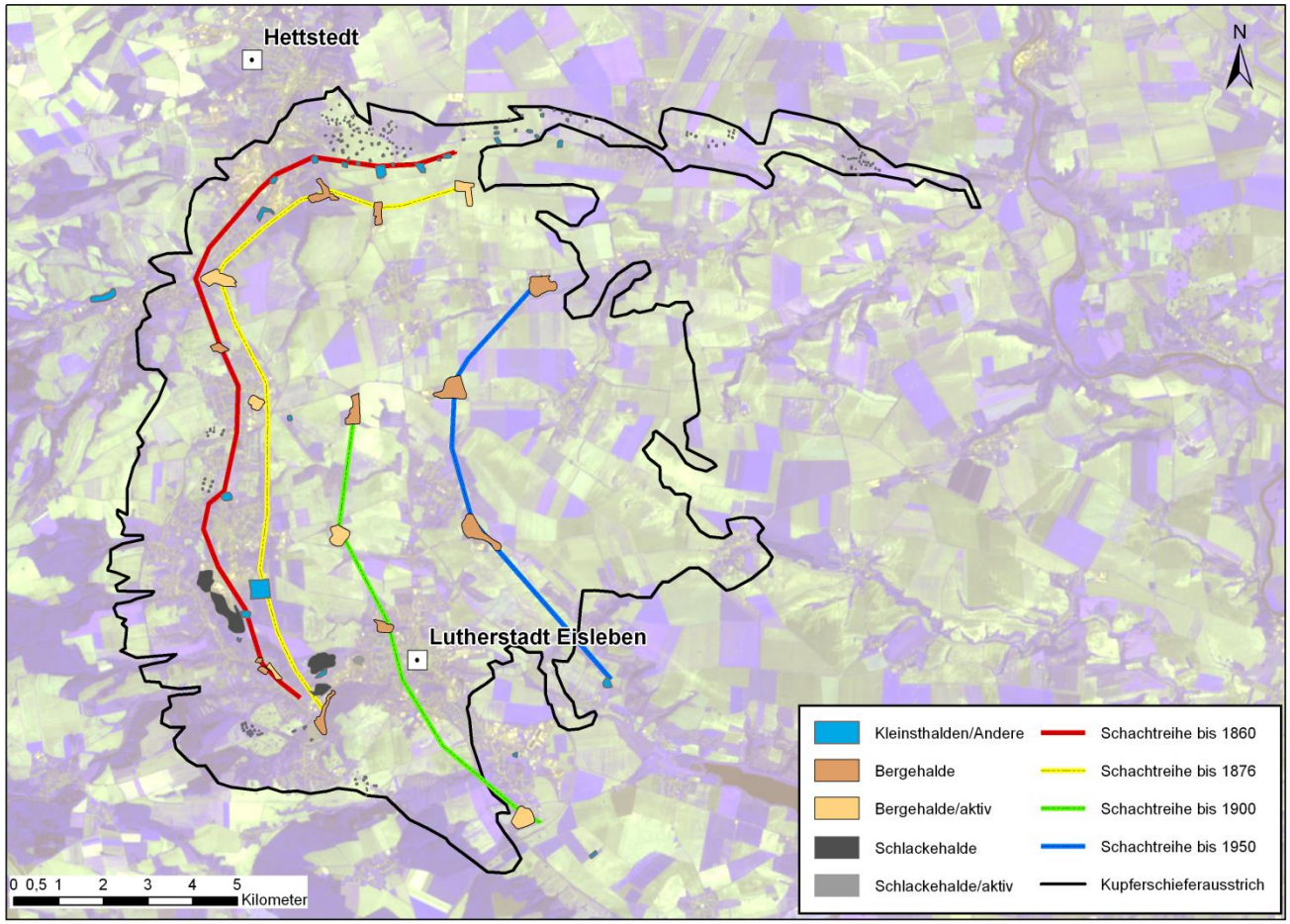
Landsat 8 - Extracted Feature (Lateritic Gravel) from Colour Composite (DELLER, 2004)
Source: USGS Products
Grid: WGS 1984 UTM Zone 30N

Author: Max Kasner
29th November 2016

Example: Classification and mapping of mining dumps

Mapping mining dumps using satellite data



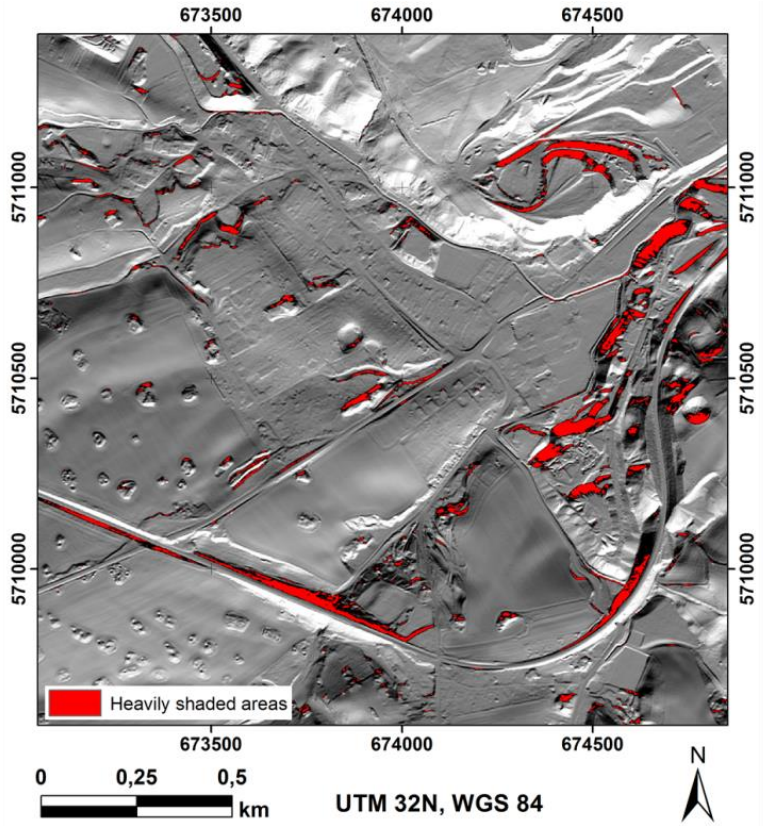
ASTER image 07.09.2006, Bands 1/2/3 als R/G/B (subset)

Slag from copper ore processing

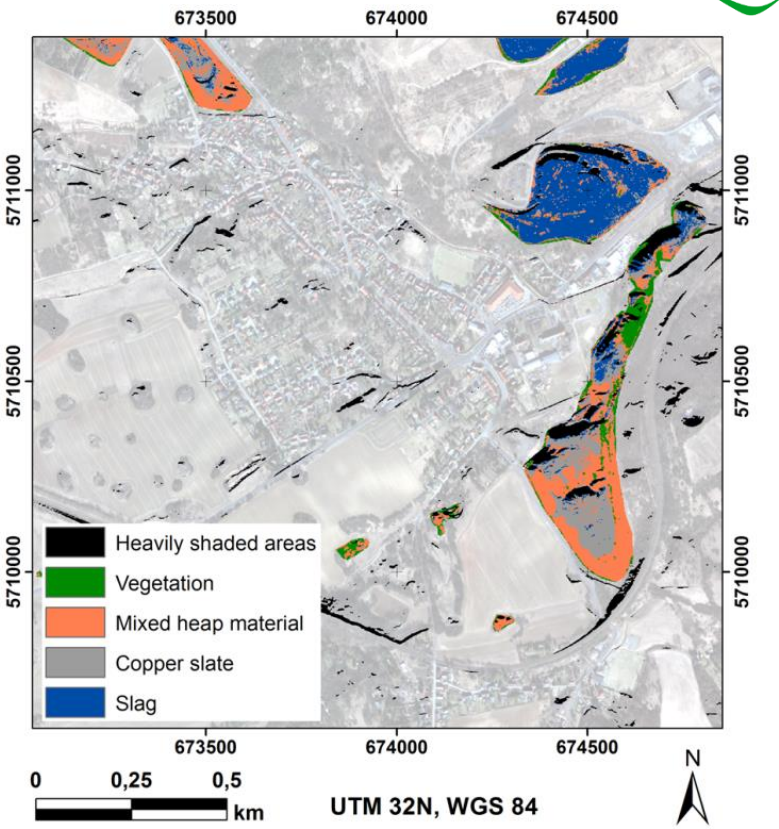
Waste rock from copper ore mining

Residuals from potash salt mining

Example: Classification and mapping of mining dumps



Shadow mask derived from DTM 1



SAM classification

From: Mrotzek-Blöß et al. 2015

Using high-resolution satellite imagery for detail analyses of individual dumps
Using high-res DEM data to assess the impact of shadows & illumination differences

Example: Advanced geological mapping methods

Spectral Feature Fitting for mineral detection

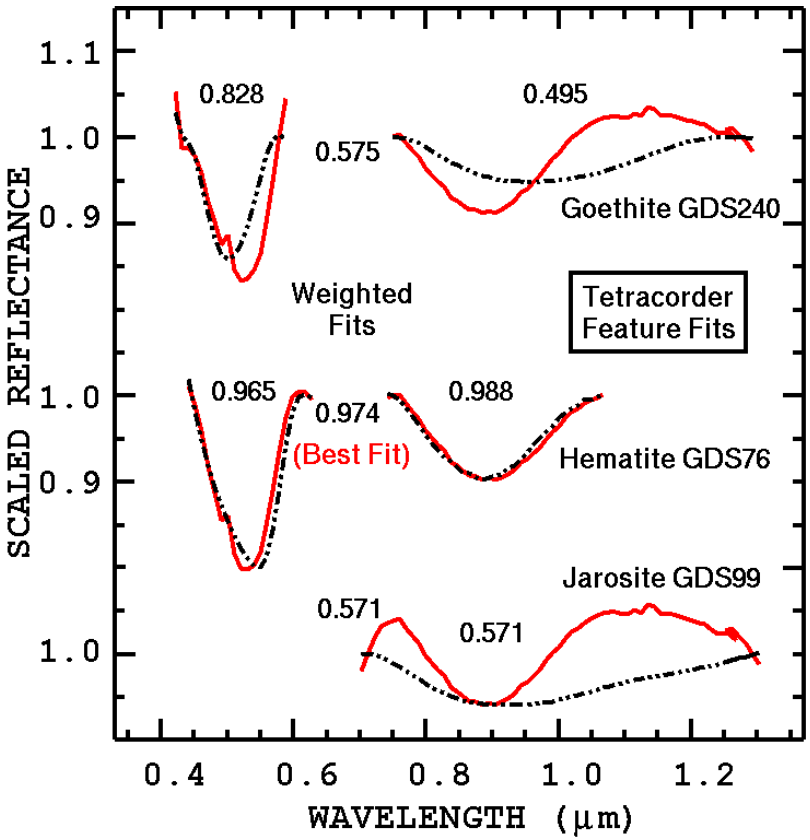
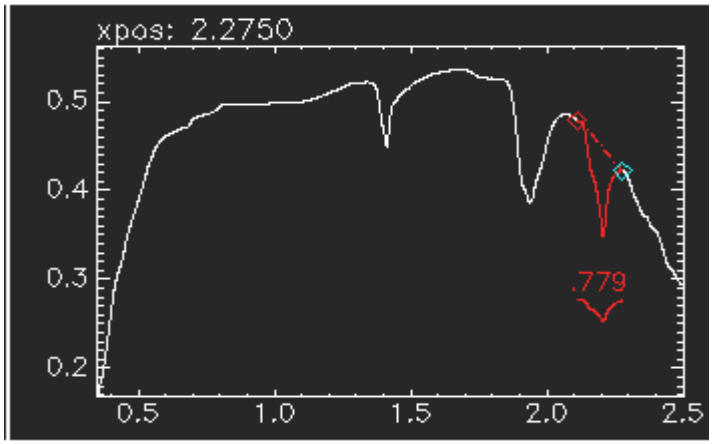
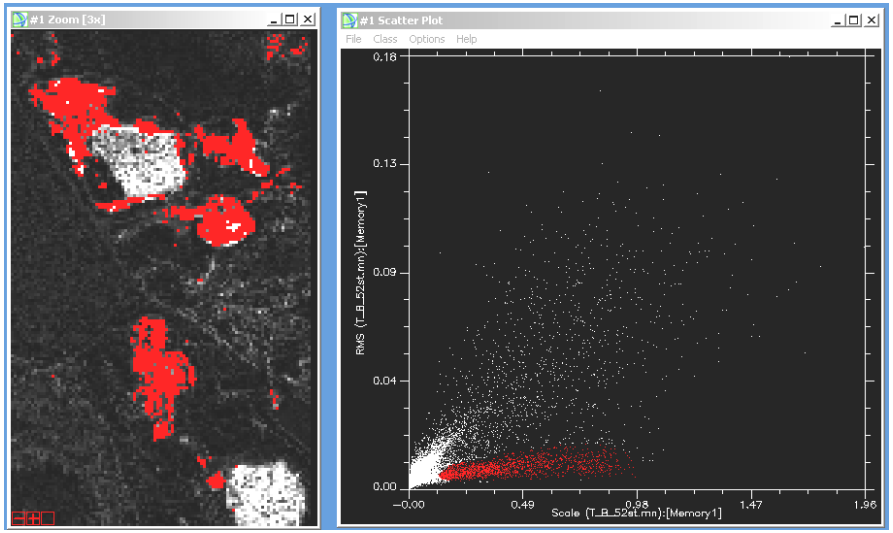


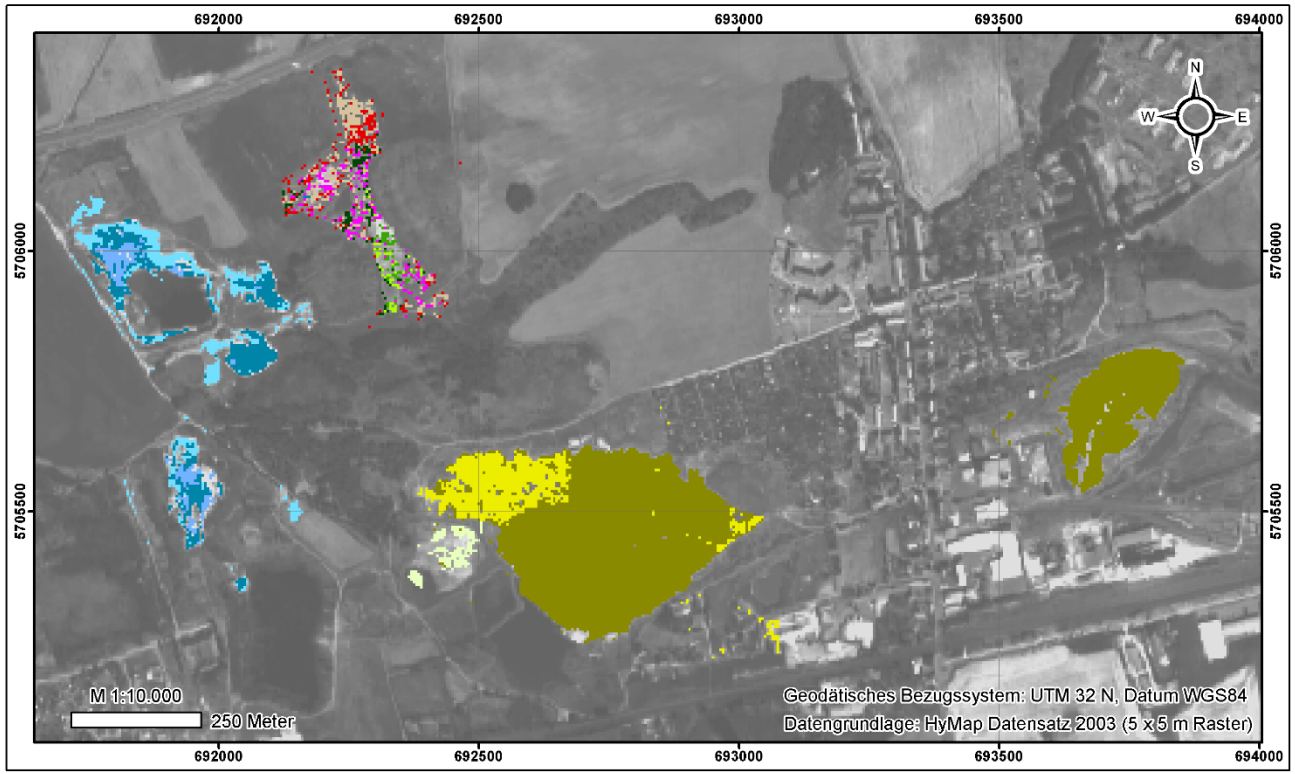
Figure from Clark et al. 2003

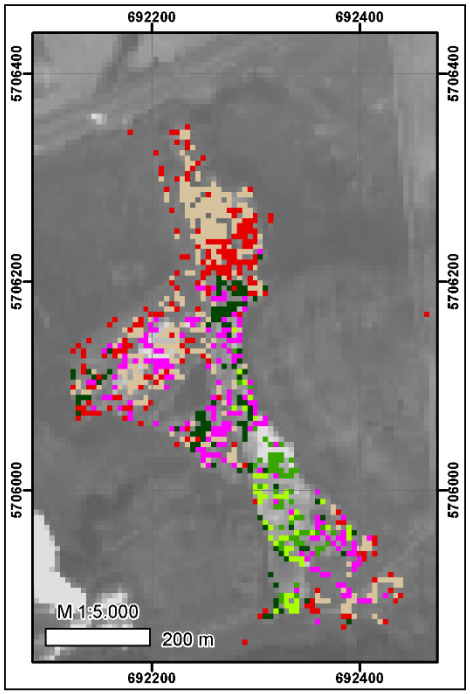




Example: Advanced geological mapping methods

Mineral classification using Spectral Angle Mapper





Ausschnittsvergrößerung der Weitzschkeniederung

Die Klassifikationen mit SAM und SFF befriedigen noch nicht.
Die Vielzahl wassergefüllter Becken, stark heterogene Oberflächen und die geringe Pixelzahl machen Unmixing Methoden erforderlich.

Legende

Gipse (Weitzschkeniederung und am Fuß der Westhalde)

- hellgraues, pulverförmiges Substrat + Epsomit (XRD: Gips, Epsomit)
- helle Auflagen, kurzprismatischer Habitus (XRD: Gips) und ockerfarbene, traubige Bildungen (XRD: Gips)
- hellbraune Kruste (XRD: Gips)
- dunkelbraune Kruste (XRD: Gips)

Sonstige Flächen in der Weitzschkeniederung

- Halit-Epsomit (XRD: Halit, Epsomit)
- graues Substrat + Halit (XRD: Quarz, Halit)
- lockeres Substrat mit roter Auflage (XRD: Quarz)

Haldenmischsubstrate

- Haldenmaterial A (XRD: Gips, Anhydrit, Calcit, Quarz)
- Haldenmaterial B (XRD: Gips, Anhydrit, Calcit, Halit, Quarz, Sylvin)

Tonminerale

- Kaolinit (XRD/USGS) + Smectit (USGS)
- Vermiculit (USGS)
- Montmorillonit (USGS)

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Thank you for your attention!

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