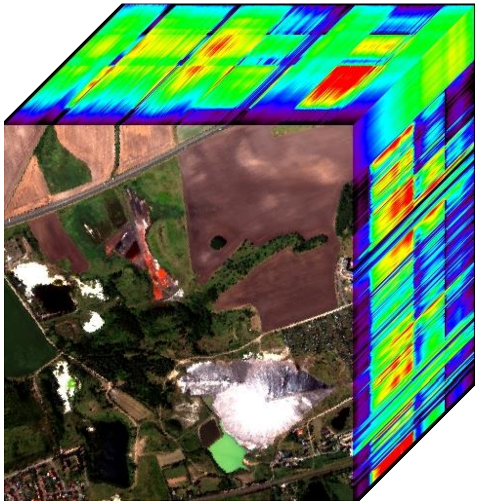
5. gemeinsame Jahrestagung der Arbeitskreise Fernerkundung der DGfG
und Auswertung von Fernerkundungsdaten der GGPF
Halle – Germany

Spectral based mapping and characterization of salt affected ecosystems in a post-mining area near Halle (Central Germany)

Daniel Schwefel & Cornelia Gläßer



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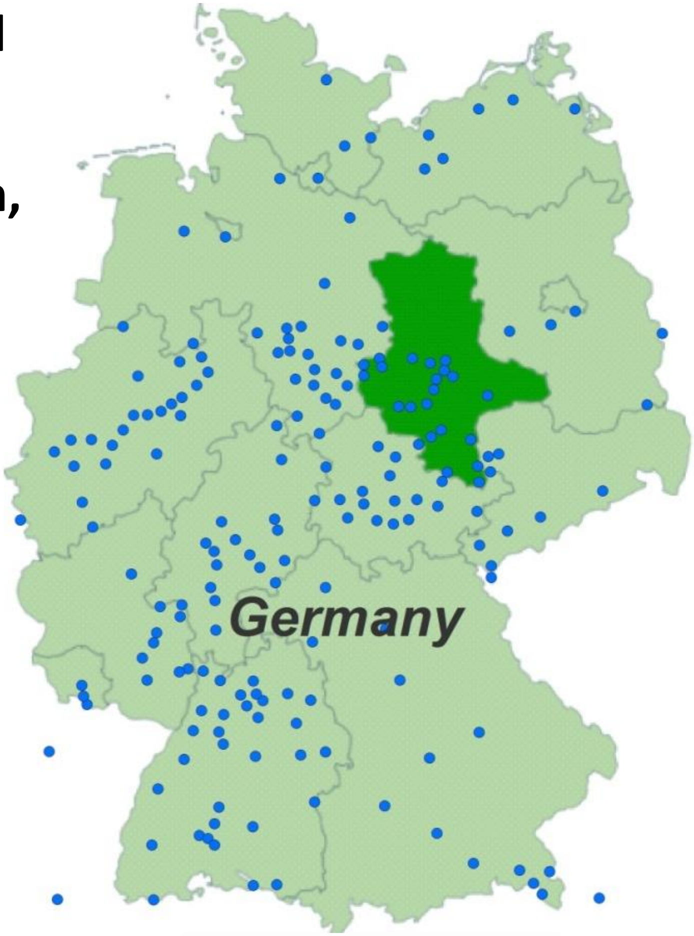
Motivation

- Tailing piles of potash salt processing causing **azonal salinizations**
- Resulting inland salt marshes constitute special habitats of **halophytes**
- halophytes are an **indicator for soil salinization,** but commonly they are only subdominant within a plant phytosociology
- Detection of halophilic phytosociologies by means of **remote sensing** data could improve analyses of **ecosystems**

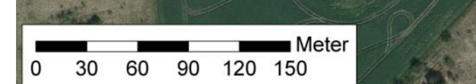

„Monte-Kali" at Heringen (Central Germany)

Locations of historical salt production



(according to Wilke, 2002)

Example: Small salt affected wetland within a field



<u>Issue</u>: Salinization and „simple“ water influent are not discriminable in standard arial photos. Halophytic species are also not visible.

Objectives

- Assessment of the suitability of **halophilic phytosociologies as an indicator** for salinization
- Investigation of the **spectral characteristics and the identifiability** of halophilic plant communities
- Detection of halophytes with hyperspectral imagery (**HyMap, Cubert, AisaDUAL**)
- **Link geochemical parameters** with the classification results to derive the condition of the ecosystem

Study site at Teutschenthal (Central Germany)

dschwefel@sphereoptics.de

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The post-mining area Teutschenthal (Central Germany)

Halophytes of the Weitzschke salt marsh

Substrat
no vegetation,
hypersaline

Suaeda maritima and Salicornia europaea
(Saltnumber 8/9, according to ELLENBERG 1991)

Salt meadows
primarily facultative halophytes

Ruderal flora
no salt influence

Gradient of salinization

> 100 g/kg — **Ø 30 g/kg** — **Ø 10 g/kg** — **< 5 g/kg**

decrease of salt content (amount of Na^+, K^+, Ca^{2+}, Cl^- and SO_4^{2-})

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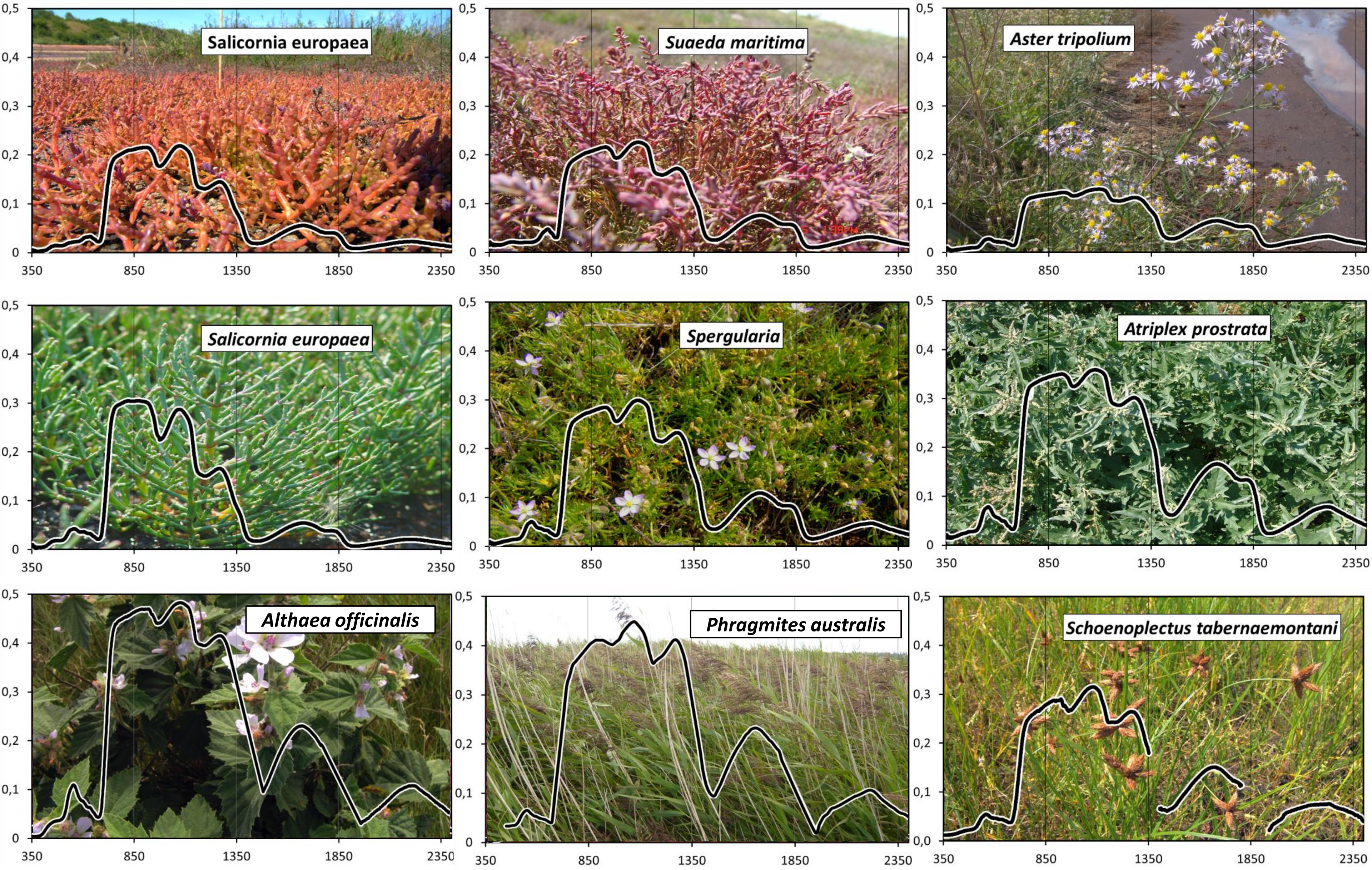
Spectral characteristics of Halophytes



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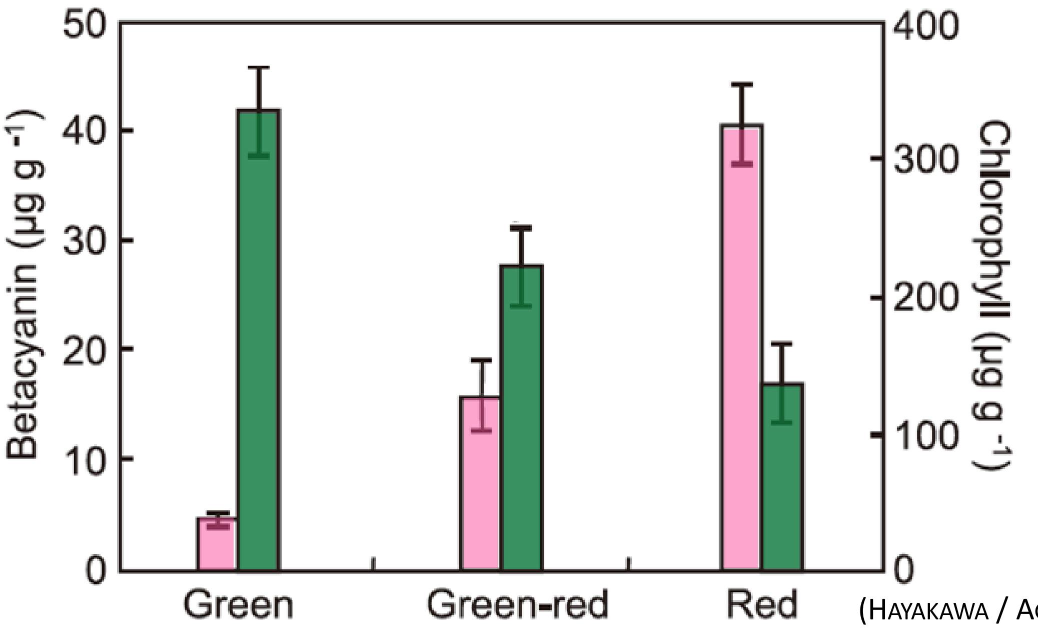
Phenological aspects of halophytes

Three phenotypic categories of leaf colours in Seablite (HAYAKAWA / AGARIE 2010):

green | green-red | red

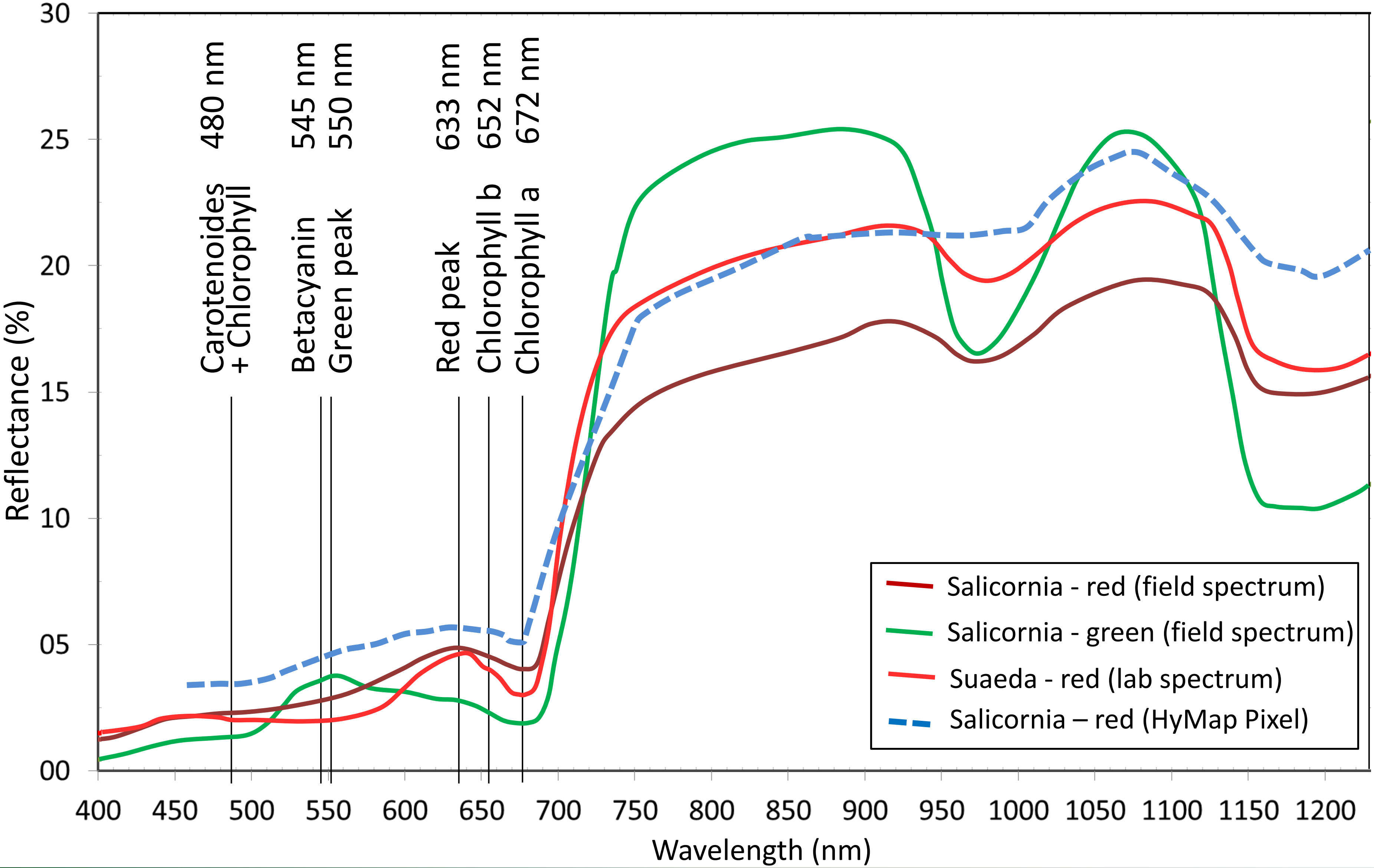


(HAYAKAWA / AGARIE 2010)

Betacyanin and **chlorophyll** contents in Seablite leaves change during the phenological phases

→ aging and stress symptom caused by salt accumulation

Typical pigments of Halophytes



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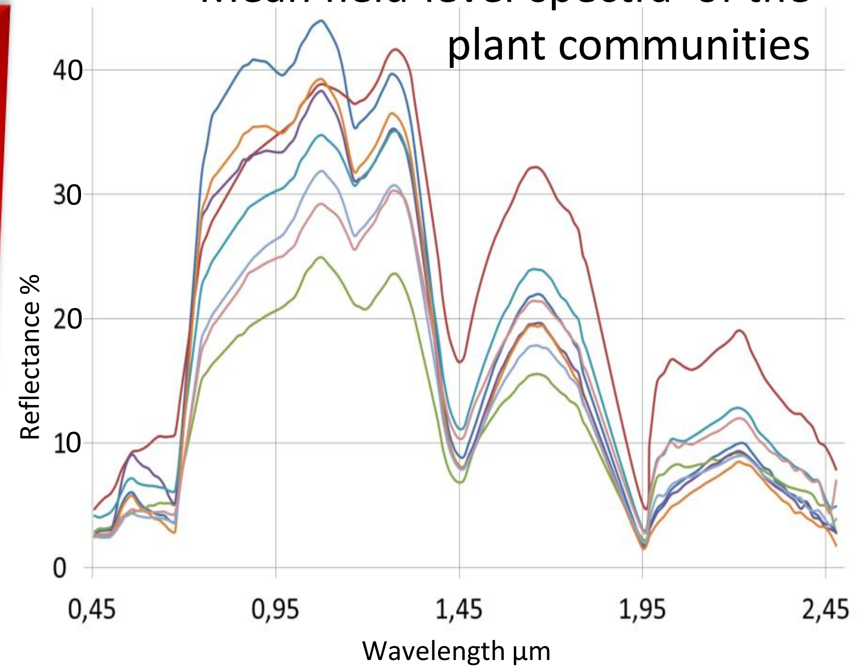
Phytosociologies in the Weitzschke salt marsh

Phytosociologies (occur as mono or dominance stands)

Bare substrate	
Glasswort meadows	*Salicornietum europaeae*
	Salicornietum mixed
Salt meadows	*Aster tripolium*
	Juncetum gerardii
	Althea officinalis
Reed communities	*Bolboschoenetum maritimi*
	Phragmitetum australis
Ruderal pioneer communities	*Calamagrostis epigejos*
	Solidargo canadensis

Mean field-level-spectra of the plant communities







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Methods - Workflow

Vegetation mapping

1999 (RANA) + 2011 - 2012
plant communities
improtant species

Spectroscopy

2009 - 2013
3 times a year (2011-2012)
canopy and field level refl.

Hyperspectral image data

HyMap: 2009-08-19, 125 bands, 450-2500 nm, 4 m

Cubert: 2016-07-14, 125 bands, 450-1050 nm

Classification

DECISION TREE

adapted thresholds of knowledge-based normalized difference indices for discrimination

Comparison

SUPPORT VECTOR MACHINE

Automated method of machine learning using HyMap spectra of target classes

Geochemical analyses

>250 soil analysis for validation and quantification

Map of salinization

Plant communities as indicator for salinization

Map of vegetation

Distribution in the Weitzschke-depression

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Suport Vector Machine

HyMap data

Date: 2009-08-19 – ideal for halophytic plant societies

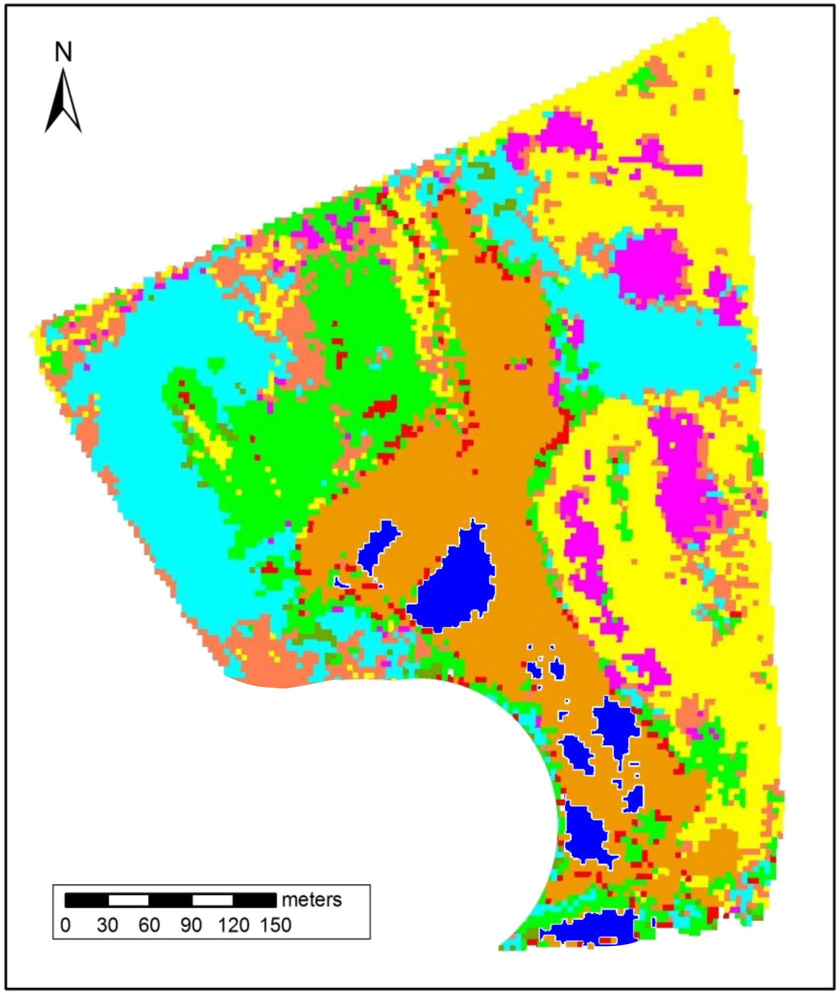
GSD: 4 m

125 bands, 450 – 2500 nm

Use of HyMap spectra (at least 20) of 10 classes (water, substrate and 8 plant phytosociologies) as base of the SVM algorithm

Bare substrate	Water	Salicornietum
Calamagrostis	Juncetum	Phragmitetum
Calamagrostis (vital)	Solidargo	Althaea o.

Classification result of SVM



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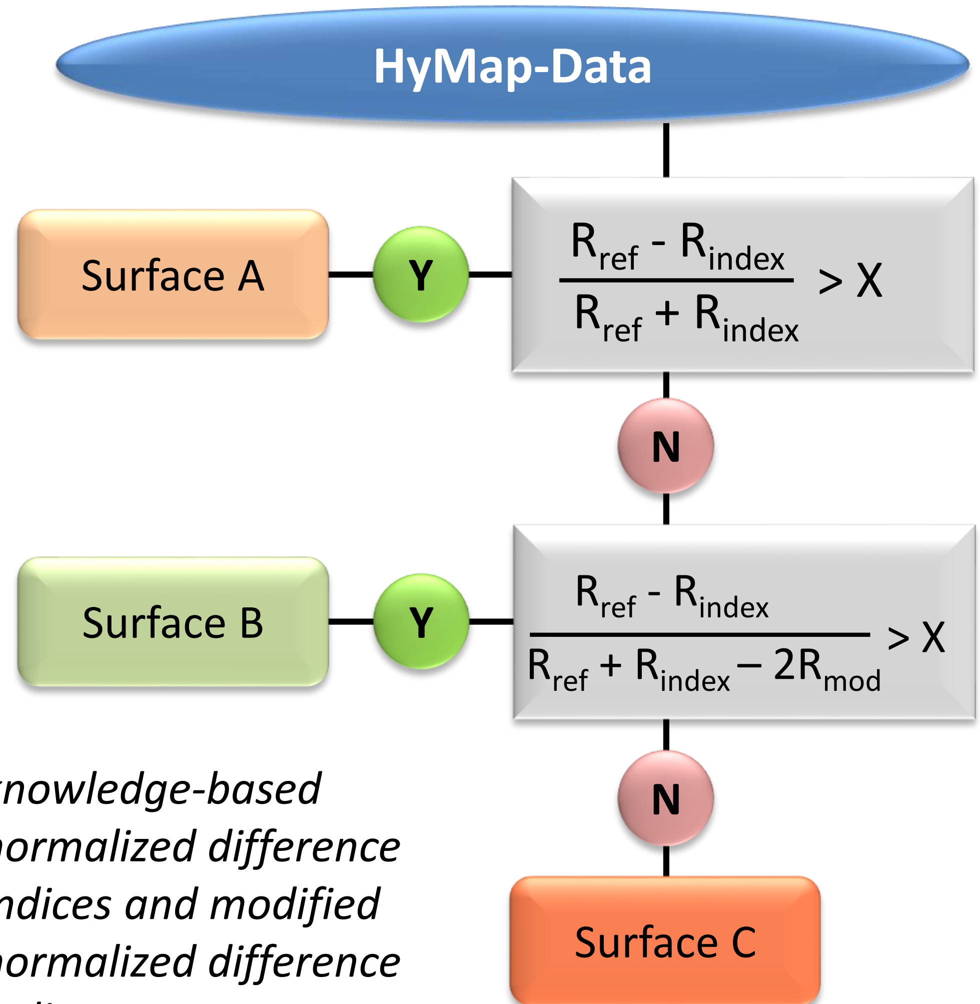
Method - Decision tree classification

Main spectral ranges for discrimination with high differences:

- Green (557 nm) and red peak (660 nm)
- Red Edge position
- Rise between 760 - 900 nm
- Depth of the water absorption band at 955 nm
- Maxima of SWIR I and SWIR II peaks (position and absolute height)
- Biochemical absorption features at the SWIR II range

Principle structure of the decision tree



knowledge-based normalized difference indices and modified normalized difference indices

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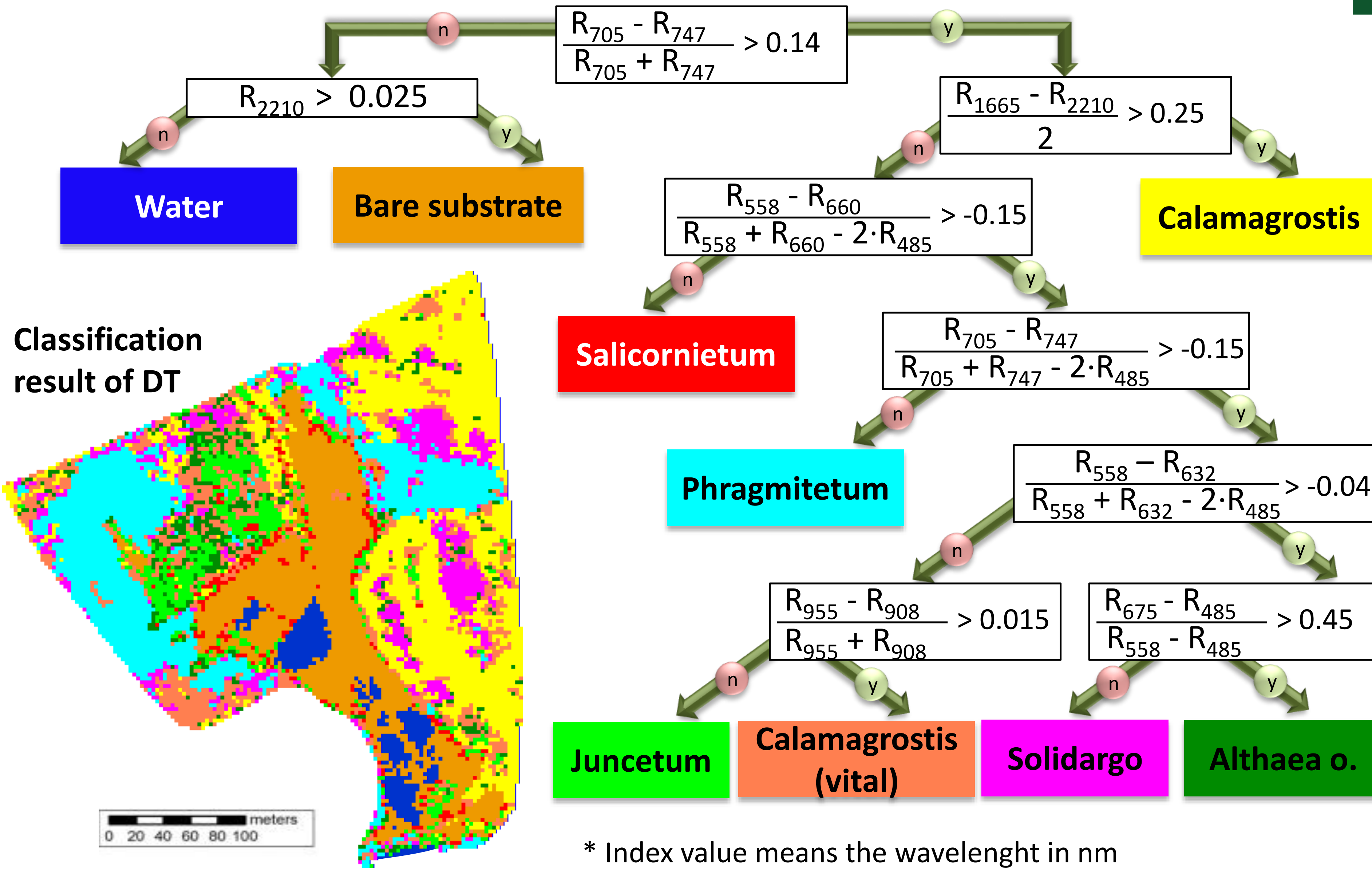
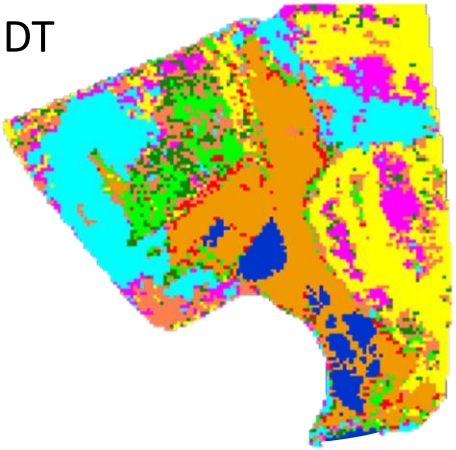
Decision tree classification – Structure and target classes



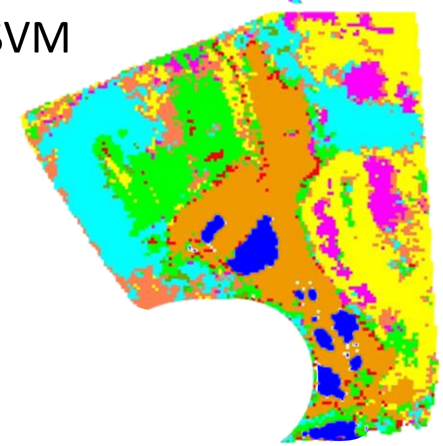
* Index value means the wavelenght in nm

Assessment and comparison of the classifications

DT



SVM



Field

		Decision Tree	Support Vector Machine	Field mapping as reference
detecting of plant communities	***Accuracy assessment***	**+ (86%)**	**+ (85%)**	**++**
	Salicornietum	+	o	++
	Aster tripolium	-	-	++
	Juncetum gerardii	+	o	+
	Althea officinalis	-	--	++
	Bolboschoenetum	--	--	++
	Phragmitetum australis	+	+	-
	Calamagrostis epigejos	++	++	++
	Solidargo canadensis	++	++	++
other	Shadows	-	--	++
	Time requirement	+	++	--
	General assessment	**+**	**+**	**++**

Key:

++	+	o	-	--
best	good	o.k.	poor	bad

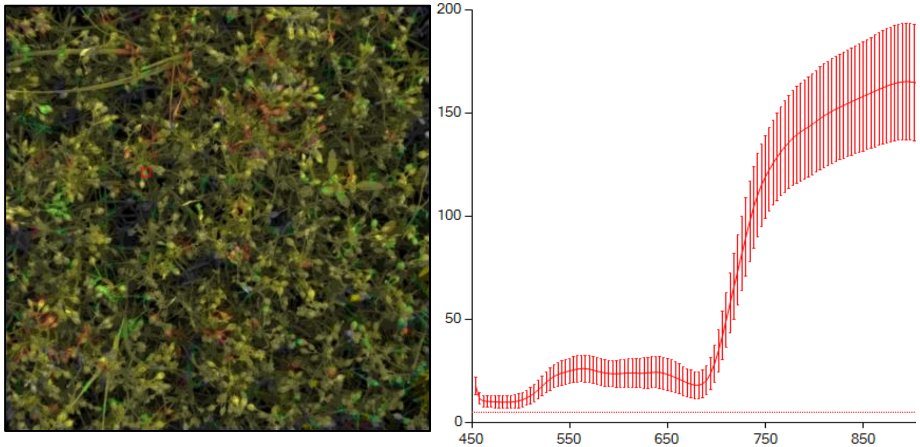
Terrestrial hyperspectral imaging - Cubert UHD 285

Snapshot hyperspectral imager:

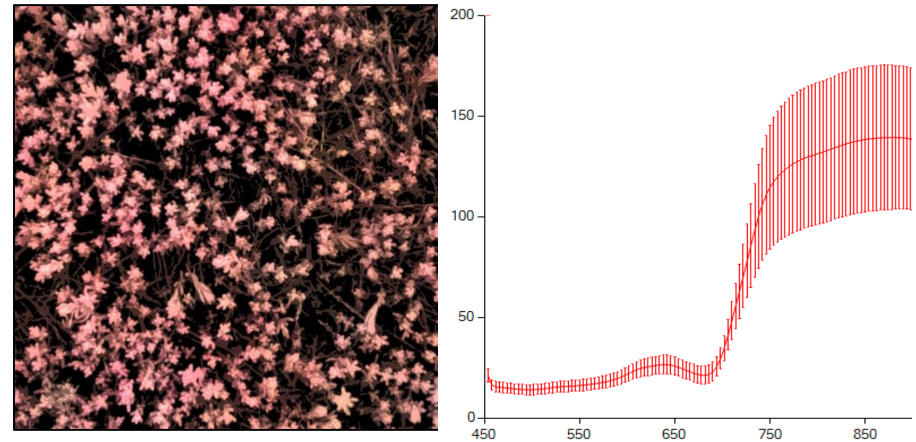
Type	Cubert UHD 285 (water proof housing)
Wavelength range	450 – 1000nm
Spectral resolution	8 nm @ 532nm
Sampling interval	4nm
Bands	125
Radiometric resolution	14 Bit

$$I_{Reflektanz} = \frac{I_{Sample} - I_{Dark}}{I_{Referenz} - I_{Dark}} \cdot R \cdot \frac{t_2}{t_1}$$

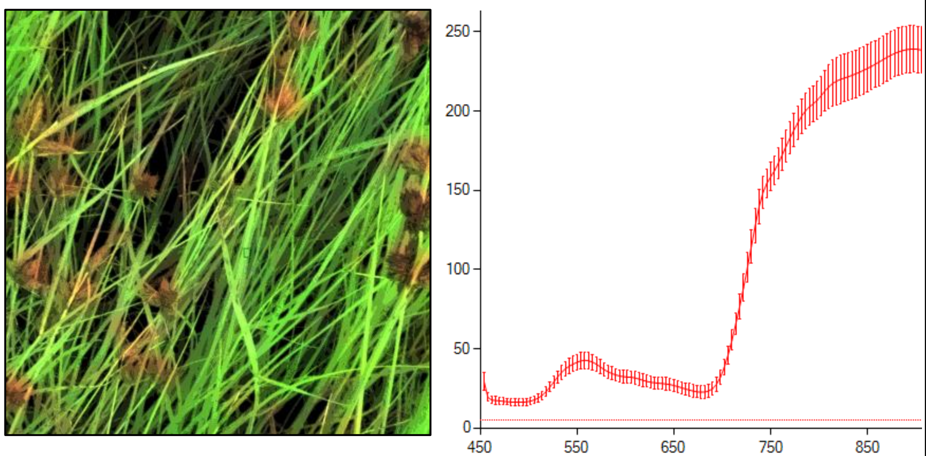
Cubert UHD 285 data – diversity within the species



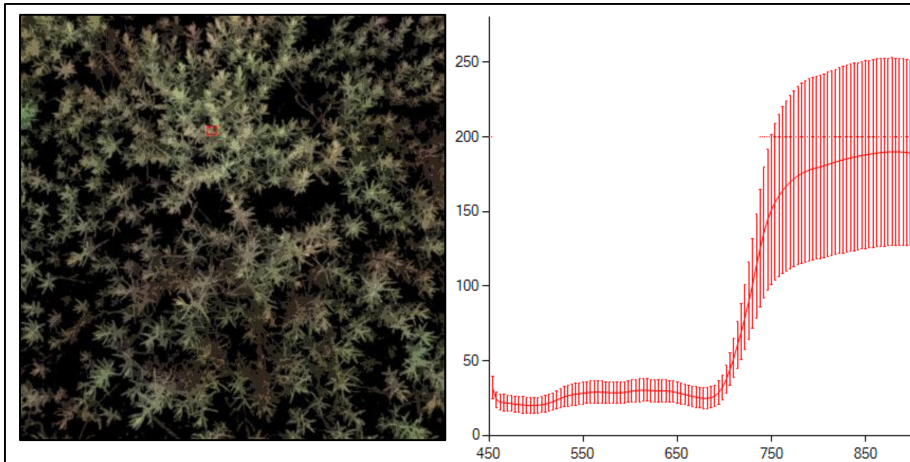
Spergularia – succulent leaves and withered blossoms



Suaeda maritima – stressed (high betacyanin content)



Schoenoplectus tabernaemontani – bulrush with fruiting bodies



Suaeda maritima – vital (high chlorophyll content)

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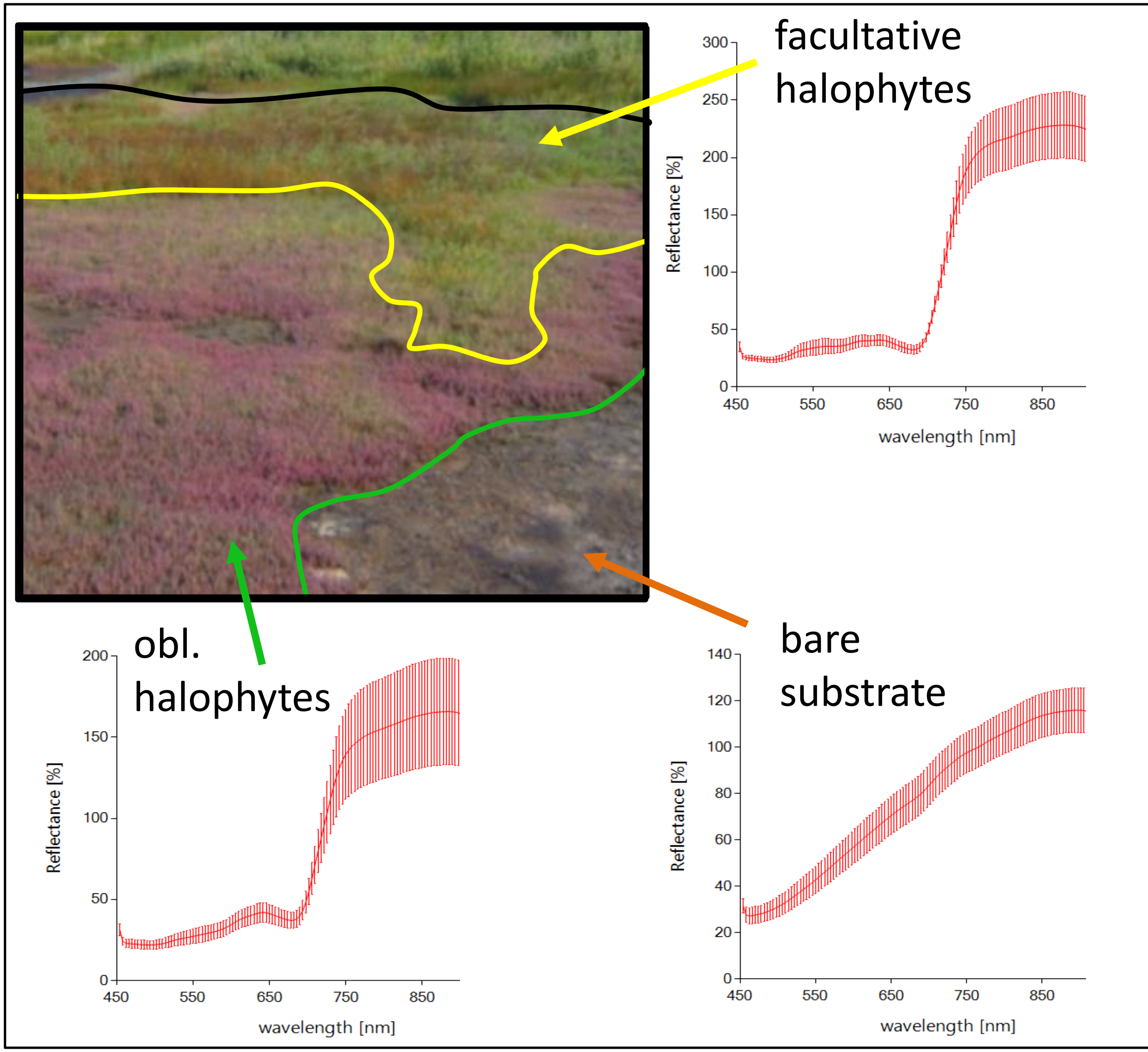
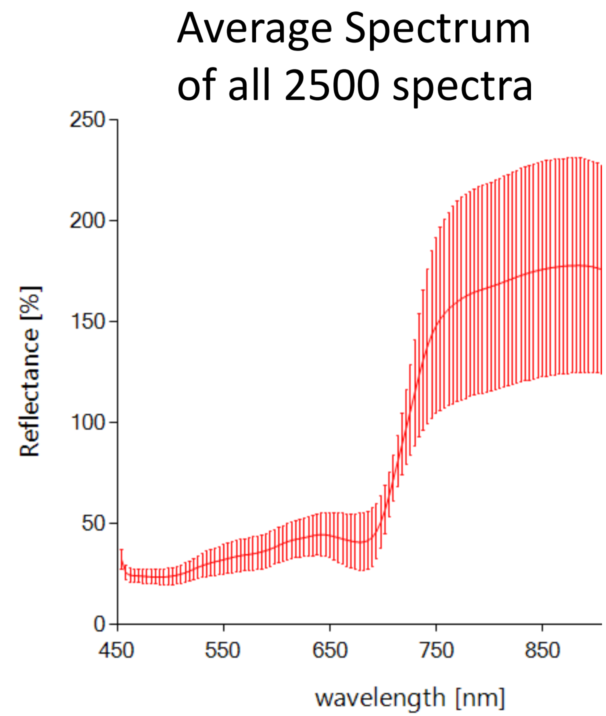
Cubert UHD 285 - Small scale mapping and upscaling

Cubert camera: 1 megapixel panchromatic resolution and 2500 spectra





Testing the effects of mixing different amounts of plant types helps for a better understanding of the target classes and to optimize the threshold settings

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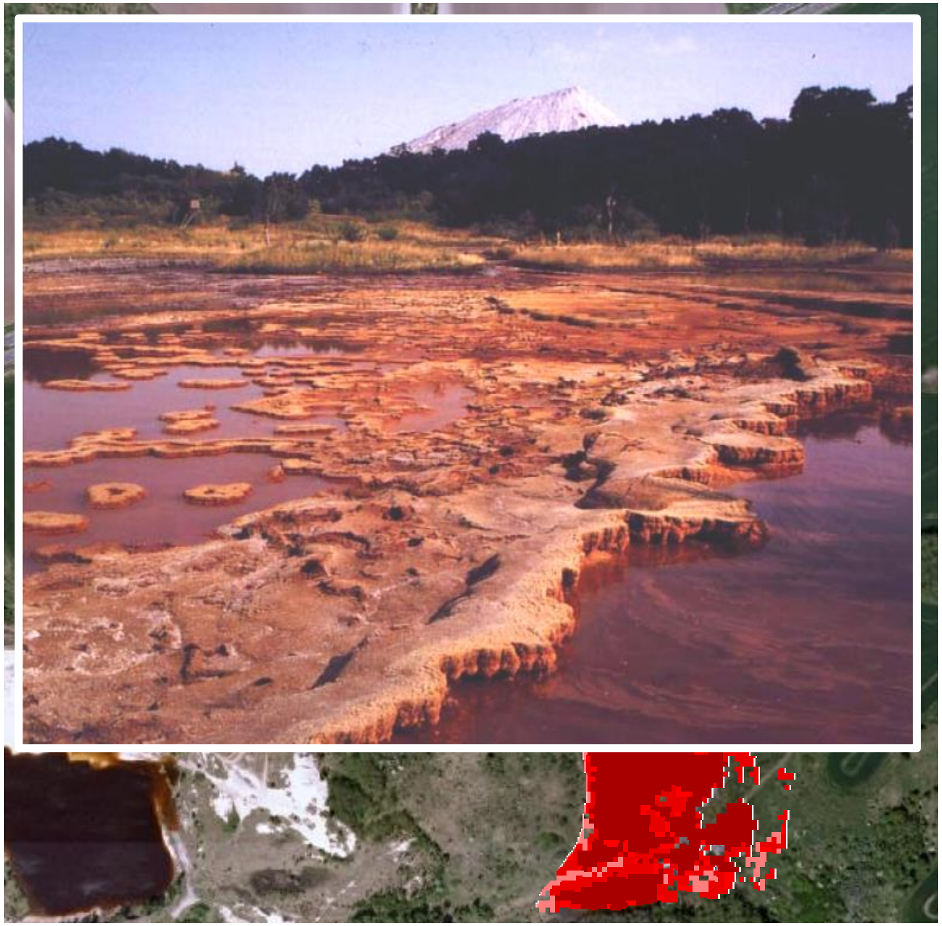
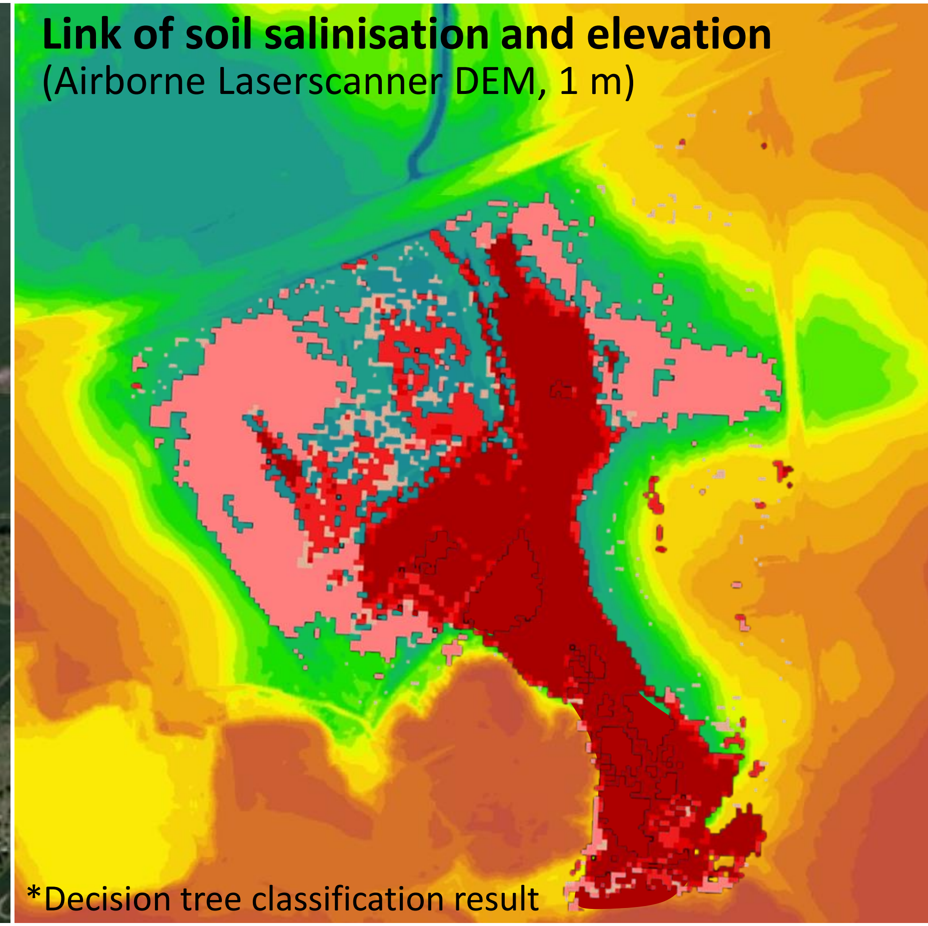
Link of geochemical parameters





> 100		> 20		> 5

Soil salinity g/kg (derived from the SVM-classification)

<88 | 88 - 88,5 | 88,5 - 89 | 89 - 89,5 | 89,5 - 90 | 90 - 90,5 | 90,5 - 91 | 91 - 91,25 | 91,25 - 91,5 | 91,5 - 91,75 | 91,75 - 92 | 92 - 92,25 | 92,25 - 92,5 | 92,5 - 93 | 93 - 94 | 94 - 95 | 95 - 96 | 96 - 98 | 98 - 100 | > 100

Elevation in meters

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Conclusion

- Soil salinization is not directly detectable with optical remote sensing data, but halophilic phytosociologies are as a matter of principle suitable as an indicator for salinization
- Spectral characteristics of halophytes allow the discrimination of other species and of halophilic phytosociologies
- Detection of halophytes by means of hyperspectral imagery is possible and deliver good classification results
- Conditions of the ecosystem can be derived by linking geochemical parameters with the classification results

» The transfer for other areas would significantly facilitate the complex field work and would also enable a more cost-effective monitoring for inland salt marshes.

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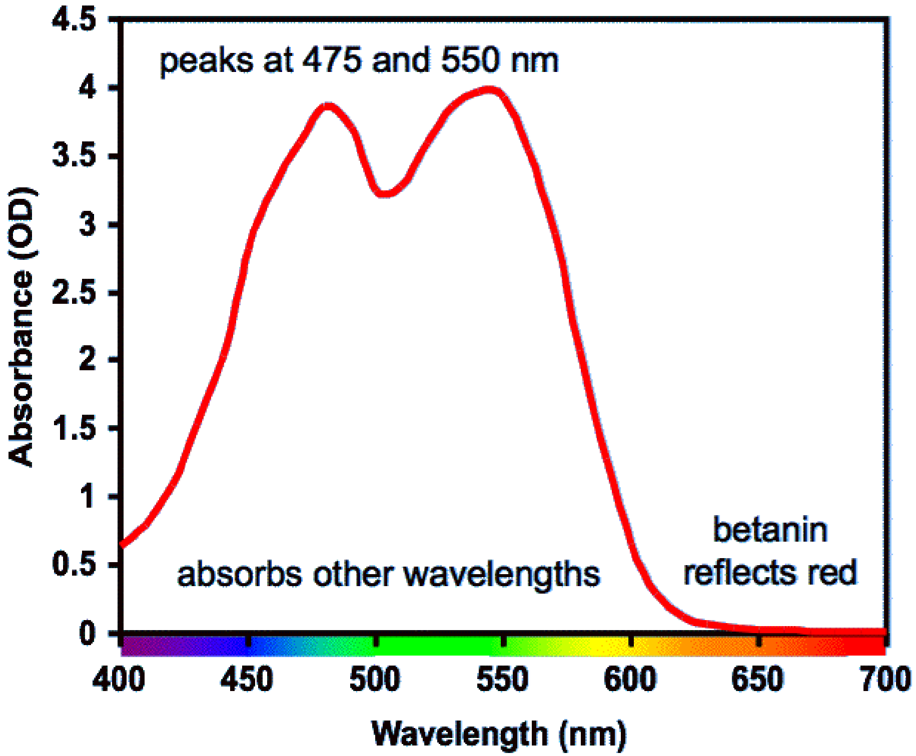
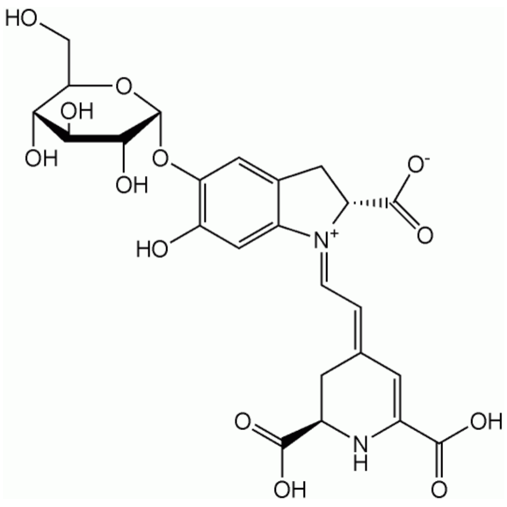


Betalains are a class of red and yellow pigments found in plants of the Caryophyllales, where they replace anthocyanin pigments.



Chemical structure of betanin (Wiki)

Koning, Ross E. 1994. Betacyanin. *Plant Physiology Information Website*. http://plantphys.info/plant_physiology/labaids/betacyanin.shtml. (4-5-2013).