Vegetation and Substrate Mapping with Hyperspectral Airborne Remote Sensing

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Introduction

Vegetation monitoring is an important tool in coastal zone management and environmental research. Common ground-based methods, such as vegetation mapping and quantitative sampling are time-consuming in the field and often spatially restricted, but provide highly dissolved biological data. Hyperspectral airborne remote sensing, in contrast, also provides highly dissolved data, but on a different biological scale.

Our approach to airborne remote sensing uses the hyperspectral imaging sensor AISA Eagle. Within two projects, Innohyp and CoastEye*, the sensor AISA Eagle was integrated into a motor glider (Fig. 1, 2) in co-operation with OHB System AG. Sensor calibration and data pre- and post-processing are jointly developed with OHB and FIELAX GmbH.

Specifically, we measure the reflectance spectra of vegetation units and different substrates. These are used for classification of hyperspectral data to create detailed thematic maps of the ground.

Fig. 1: Motor glider with the wingpod (Photo: OHB).

Fig. 3: Rocky intertidal in the north of Helgoland.

Research Goals

- Hyperspectral classification of macroalgal species
- Analysis of their spatial-temporal change through different seasons
- Quantify change
- Develop a synoptic and objective monitoring tool for the future
- To build a spectral library with the help of reflectance spectra from field measurements

Fig. 2: Sensor and equipment in the wingpod (Photo: OHB).

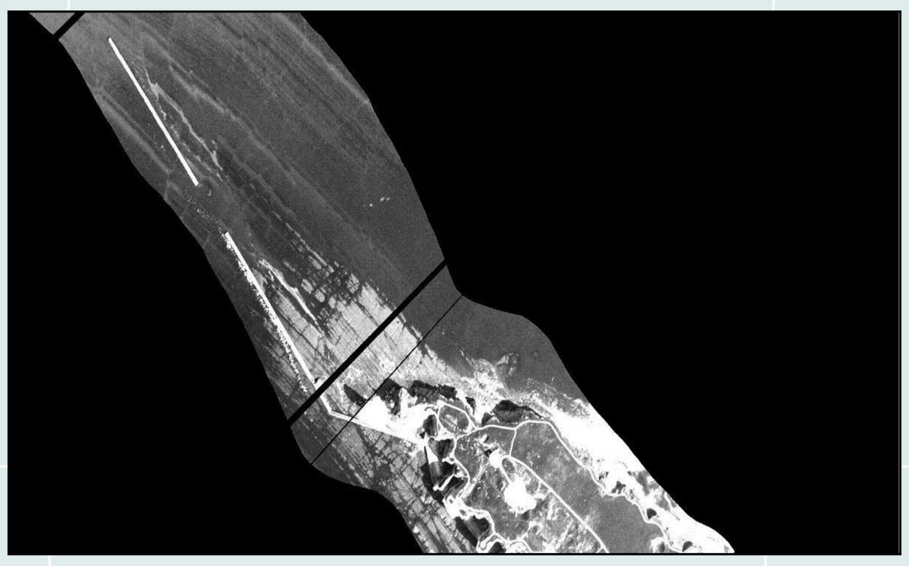

Fig. 4: Grayscale hyperspectral scene of the northern area from 09 May 2008, pre-processed.

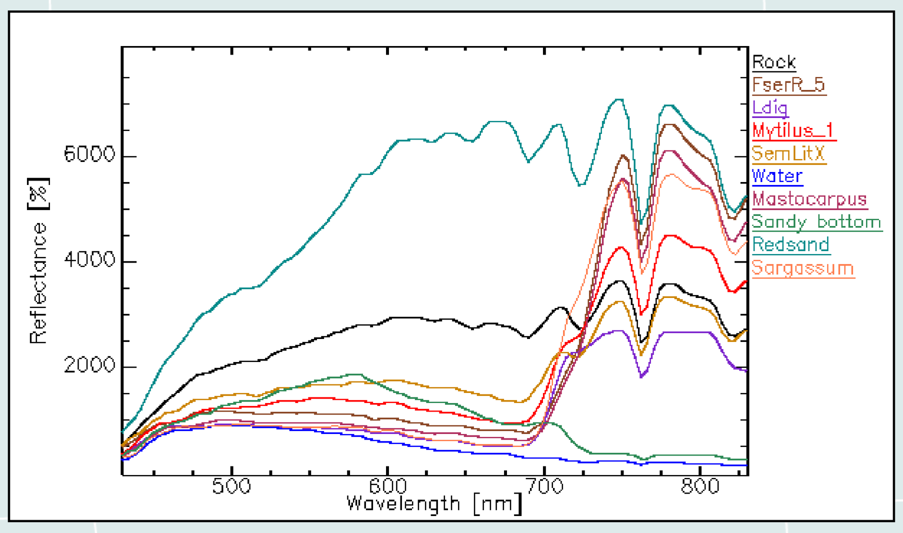

Fig. 5: Endmember spectra from the scene in Fig. 4.

Research Area

The main research area is the rocky intertidal of Helgoland (Fig. 3), which is characteristic for its rich macroalgal vegetation. Within CoastEye other coastal sites will be sampled as well.

Data Acquisition

- Measurement campaigns:
    - Test campaigns in late 2007 and early 2008
    - First main campaigns in April and May 2008
- Measurement conditions
    - Only at low tide
    - Only during clear sky conditions, since clouds have a significant influence on hyperspectral sensing and light availability

The hyperspectral data is validated with vegetation mapping and simultaneously collected field spectroscopy data.

Technical Equipment

AISA Eagle (AWI)
- Hyperspectral imaging sensor from Specim Ltd
- Spectral range: 400 - 970 nm
- Spectral resolution: 2.9 nm
- Up to 488 spectral channels
- FOV (field of view): 37.7°
- Ground resolution at 1000 m altitude: 68 cm

Motor glider Condor Stemme S10 (OHB)
- Max. speed: up to 270 km/h
- Min. speed: approx. 30 km/h
- Modified to accommodate two wing pods (60 kg per pod)
- Mission duration: more than 7 h

Field spectrometer HandySpec from tec5
- Spectral range: 400 - 1100 nm
- Spectral resolution: 3.3 nm
- FOV (field of view): 25°

Data Processing

The pre-processing of the scenes after the flight consists of georectification, georeferencing, and radiometrical correction (Fig. 4).

Post-processing involves spectral and spatial data reduction (Minimum Noise Fraction and Pixel Purity Index) and n-dimensional visualization for endmember spectra extraction (endmembers are defined as spectrally pure features). These endmembers (Fig. 5) are then classified by using statistical methods (e.g., Spectral Angle Mapper) based on the vegetation mapping and field spectroscopy. This results in a thematic map in which each vegetation/substrate unit is represented by an unique color.

The particular challenges are the decomposition of pixels that correspond to areas with mixed vegetation and the distinction of similar spectra (e.g., those of three species of brown algae, Fig. 6). First results indicate, that the ratios 576/603 and 768/810 (Fig. 7) are suitable for the differentiation of three major brown algal genera (Laminaria, Fucus and Sargassum).

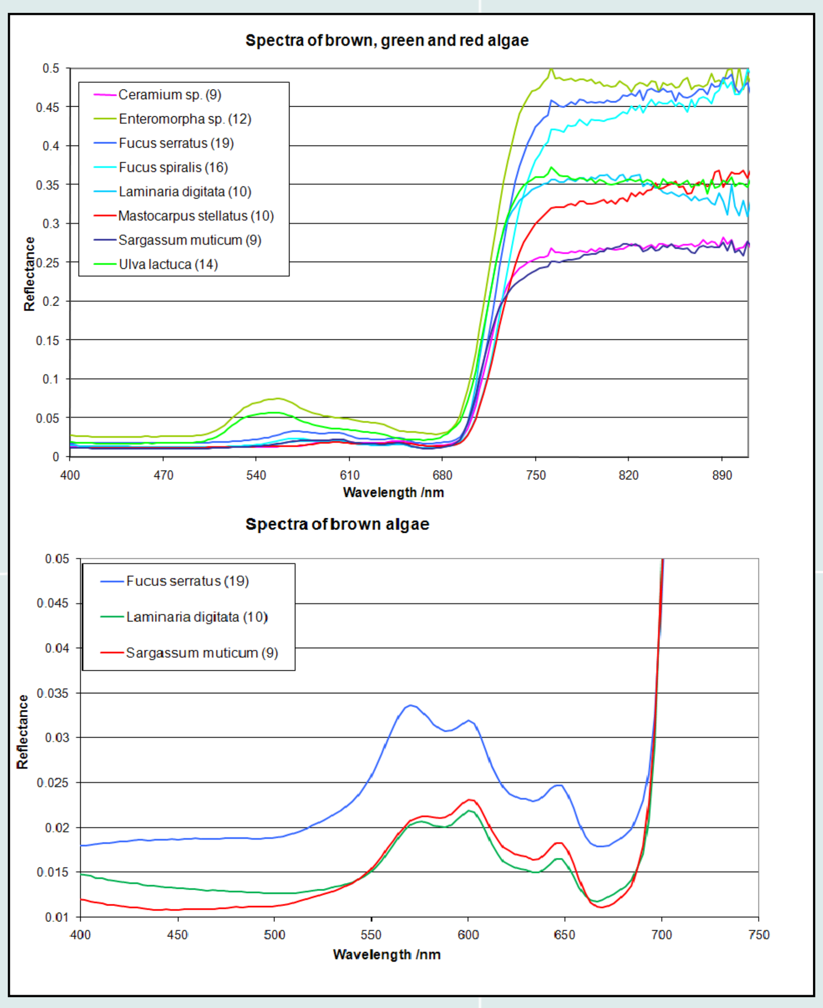

Fig. 6: Field spectroscopy data of some macroalgae: hole spectrum and wavelength range 400-750 nm (only brown algae).

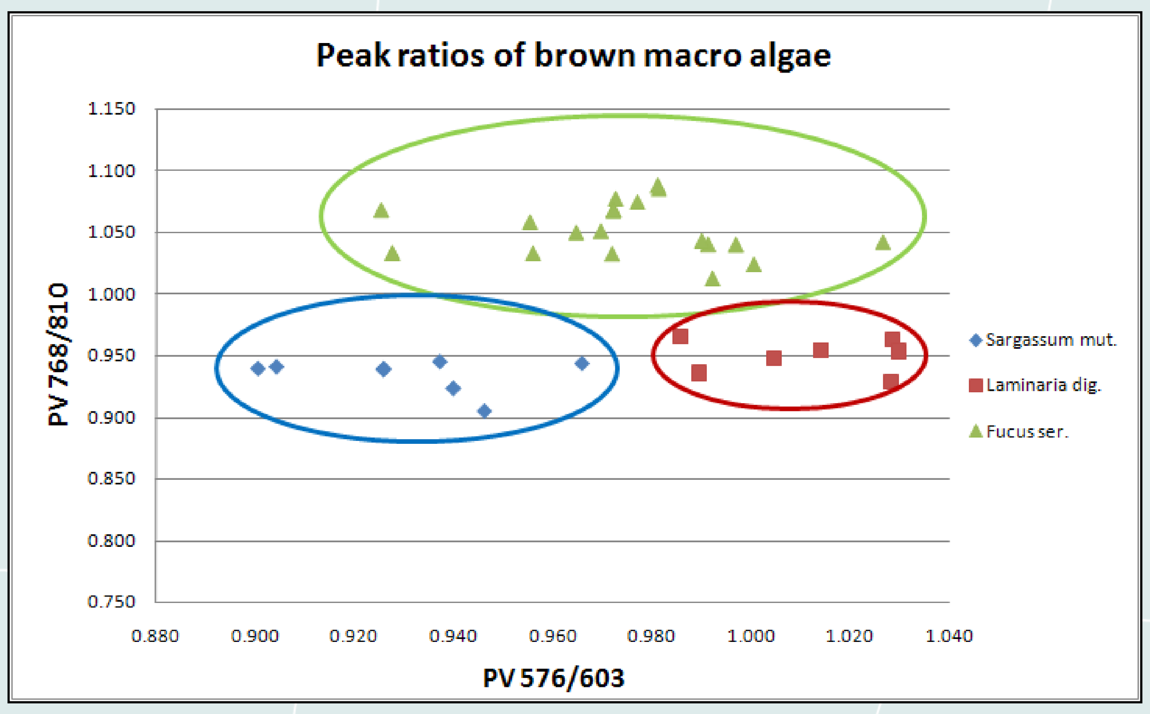

Fig. 7: Peak ratios of the pure spectra of three dominant brown algae.

Summary

- We use hyperspectral airborne remote sensing for vegetation mapping.
- Validation of the hyperspectral data with field spectroscopy
- The combination of peak ratios 576/603 and 768/810 allow the differentiation of three dominant brown algal genera.

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