DIFFERENTIATION OF BROWN SEAWEEDS BY HYPERSPECTRAL AIRBORNE REMOTE SENSING AND FIELD SPECTROMETRY IN A ROCKY INTERTIDAL

Presented at the 6th EARSeL SIG IS workshop, 16 - 19 March 2009, Tel Aviv

Christina Mehrtens[1], Tina Kaschell[1], Frederic Tardeck[2], Nora Graser[2], Carsten Borowy[3], Inka Bartsch[1]

Introduction

Hyperspectral airborne remote sensing provides a time-efficient method for collecting high resolution data for middle-scale areas. We observed the seasonal development of rocky intertidal seaweed assemblages at the island of Helgoland (Germany, North Sea, Fig. 1) by using the hyperspectral imaging sensor AISA Eagle which is attached to a motor-glider by a wingpod (Fig. 2). Field spectroscopy of visually dominant seaweeds was used to build a spectral library. The major challenge is to distinguish the seaweed dominated assemblages characterized by different brown, green, or red algal genera and mixtures of them based on their spectral reflectance. We present an approach that uses a Gaussian Mixture Model as probabilistic classifier based on the spectral wavelength ratios of selected wavelengths for the differentiation of brown seaweeds.

Research Goals

Hyperspectral classification of intertidal seaweed genera based on reflectance spectra from field measurements.

Research Area

The rocky intertidal of Helgoland, situated in the German Bight (Fig. 1) which is characteristic for its rich seaweed vegetation.

Data Acquisition

- Measurement campaign: 6-22 May 2008
- Measurement conditions: low tide, 20 km sight, 800 W/m-2 incoming irradiance, clear sky

Spectral Differentiation with a Gaussian Mixture Model

One particular challenge is the distinction of similar spectra (e.g., those of three species of brown algae, Fig. 3). In recent papers, wavelengths were used for identification for macrophytes (1). Gaussian Mixture Models were used before in hyperspectral remote sensing, but with a different goal (2). Our approach is unique in combining of wavelength ratios and a Gaussian Mixture Model (GMM) for differentiation of field spectra.

GMM can be used as a learning-based classifier. It models the probability density of observed variables using a multivariate Gaussian mixture density. Given a series of inputs, it refines the weights of each distribution through expectation-maximization algorithms.

Procedure

- Calculating wavelength ratios of approx. 800 spectra (examples, see Fig. 4) in the range 400 nm to 800 nm, spectral resolution 3 nm (results: approx. 17000 ratios)
- Calculating the standard deviation of each normalized ratio
- Selecting ratios with high inter-ratio standard deviation for the GMM
- Visual interpretation and selection of the best combination of the ratios

First Results

- the wavelength ratios 567/593 and 540/567 are suitable for the differentiation of the brown algal genera *Laminaria* and *Sargassum* from *Fucus* (Fig. 5)
- the ratios 543/564 and 480/531 differentiate visually similar *Laminaria* and *Sargassum* (Fig. 3 and 6)
- next step is to validation of results with spectra from the hyperspectral airborne images and to classify the obtained images using our classifier.

Literature

(1) Pinnel, N.: A method for mapping submerged macrophytes in lakes using hyperspectral remote sensing, PhDthesis, *University of Munich,* **2007**

(2) Acito, N.; Corsini, G. & Diani, M.: An unsupervised algorithm for hyperspectral image segmentation based on the Gaussian Mixture Model. *International Geoscience and Remote Sensing Symposium,* **2003**

Fig. 1: Helgoland situated in the German Bight.

Fig. 2: Motor glider with hyperspectral sensor and equipment in the wingpod (Photo: OHB).

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
- 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

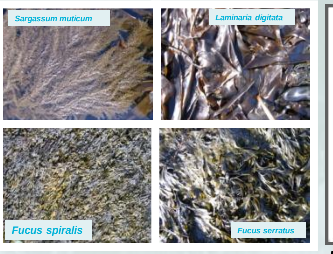

Fig. 3: Examined brown algae.

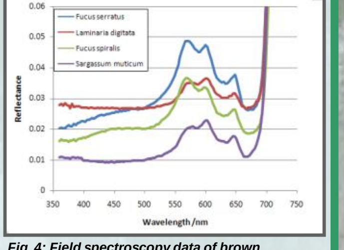

Fig. 4: Field spectroscopy data of brown macroalgae, wavelength range 400-750 nm. Infrared range (not shown) does not reveal clear differences

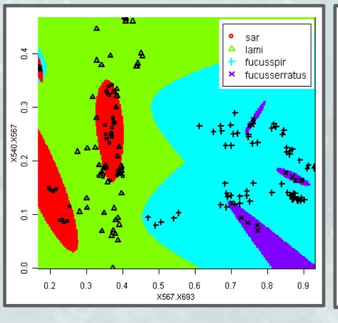

Fig. 5: Wavelength ratios 567/693 and 540/567 for four brown algae (Sar = Sargassum muticum, lami = Laminaria digitata, fucusspir = Fucus spiralis, fucusserratus = Fucus serratus). The Fucus genera are clearly distinctable from Laminaria and Sargassum. The colours indicate the classification (corresponding class has the highest probability densitiy).

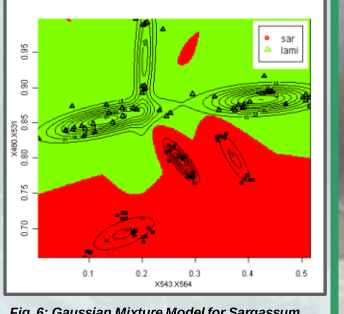

Fig. 6: Gaussian Mixture Model for Sargassum and Laminaria for wavelength ratios 543/564 and 480/531. The contours of areas with high probability density are shown. Colours indicate the distinction of the two brown algal genera using our approach.

Summary

- We use hyperspectral airborne remote sensing for mapping of intertidal macroalgae.
- Differentiation of field spectra based on Gaussian Mixture Models.
- The combination of wavelength ratios 567/593 and 540/567 allow the differentiation of the brown algal genera Laminaria and Sargassum from Fucus.
- The combination of wavelength 543/564 and 480/531 allow the differentiation of the brown algal genera Laminaria and Sargassum.
- Our results from field spectroscopy of dominant brown algae of the order Fucales and Laminariales indicate that species of the same genus are difficult to distinguish while differentiation between brown algal genera (Fucus, Sargassum, Laminaria) is possible.

1 AWI Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft
www.awi-bremerhaven.de

2 FIELAX

3 OHB SYSTEM

The research was conducted within the framework of the two projects Innohyp and CoastEye in co-operation between AWI, FIELAX GmbH and OHB and are financed by BIS Bremerhaven (project code: 68202/2-Z) and BIG Bremen (project code: INNO 104 1B)

Christina Mehrtens
AWI
Am Handelshafen 12
27570 Bremerhaven

phone: +49(471)4831-1531
fax: +49(471)4831-1425
Christina.Mehrtens@awi.de