The impact of bio-physical thresholds on sediment analysis through field reflectance spectra and hyperspectral imagery

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Introduction

The effects of biological, physical, and sedimentological factors and processes play a major role in the fate of an intertidal flat. Non-cohesive sandy particles behave autonomously depending on their diameter and density, while cohesive silt and clay particles aggregate and act in groups (Mitchener and Torfs, 1996). Furthermore, some organisms stabilize the sediment surface against suspension by secreting mucilaginous films (Murphy *et al.*, 2009), while others may destroy the “biostabilizing” structure of the sediment and thus weaken it (Widdows and Brinsley, 2002). The importance of such mechanisms in determining sediment stability leads to a need for frequent and intense field data collection. Remote sensing technology offers an alternative to traditional field sampling. It required a lower amount of typical field samples to obtain sufficient spatial coverage of information. This technology has been successfully utilized to characterize and quantify sediment properties (Rainey *et al.*, 2003; Ibrahim and Monbaliu, 2011; Ibrahim *et al.*, 2014).

Characterization of sediment using remote sensing technology has commonly used supervised classification of imagery, which assembles data into certain groups based on their similarity to pre-defined classes. A successful supervised classification leads to high accuracy and reveals the pre-defined classes of interest. It requires field knowledge to set its training and validation data. Yet, defining the boundaries between classes of sediment properties such as moisture content and mud content have been typically determined using case-specific field data or from experience and intuition. Thus, class boundaries for a sediment property are often defined using an ad-hoc procedure aiming for an equal amount of field samples in each class (Defew *et al.*, 2002). For example, Thomson *et al.*, (2003) used thresholds of 30% mud and 50% mud to distinguish between ”Sandy” and ”Muddy Sand” classes, and ”Muddy Sand” and ”Mud” classes, respectively. On the other hand Adam *et al.*, (2006) considered the ”Sand” class to include less than 15% mud, ”Loamy Sand” has between 15 and 30% mud, and ”Clayey Loam” contained more than 30% mud. Mud refers to cohesive particles smaller than 63µm.

The aim of this study is to understand the sensitivity of classification accuracy to the choice of thresholds when classifying intertidal sediment properties. Furthermore, it aims at classifying imagery of the study area using the thresholds that lead to relatively high classification accuracy.

Data and methods

The “IJzermonding”, an intertidal flat located at the outlet of the IJzer river at the Belgian coast, is used as a case study for this work. It is a nature reserve that consists of dunes, marshes, and mudflats with a total area of 130 hectares. Three flight campaigns took place over the IJzermonding at cloud-free and low-tidal conditions. On the 17th of June 2005, an image was acquired by means of the Airborne Hyperspectral Sensor (AHS) with a 3.4m × 3.4m pixel size. On the 12th of June 2007, an image was obtained by AHS, with a 3m × 3m pixel size. Finally, on the 9th of July 2013, an image was acquired by Airborne Prism EXperiment (APEX) sensor with a 2.3m × 2.3m.

Field campaigns were carried out on the intertidal flat, at low tide, to accompany the acquired images. For each campaign, sampling sites were chosen such that the highest diversity in sediment properties was included. A Differential Global Positioning System (DGPS) determined the coordinates of the sampled sites. Surface sediment samples were collected for pigment analysis, moisture content, mud content, and organic matter content quantification. Surface reflectance was measured by an Analytical Spectral Device (ASD) spectrometer that records reflectance from 350 - 2500nm, i.e. in the visible, near-infrared, and shortwave infrared regions of the spectrum.

The approach in this work can be summarized in the following steps. First, field data that includes field spectra and their corresponding sediment properties are classified using a series of thresholds for each sediment property. This aims at developing a sensitivity analysis to determine the impact of threshold choice on classification accuracy of the considered sediment properties. The classification is carried out using Support Vector Machines. Then, the thresholds for each sediment property that lead to the best classification accuracy are extracted. Finally, the obtained thresholds are used to classify the hyperspectral images of the IJzermonding.

Conclusions

Given a hyperspectral image accompanied by field data, it is required to classify the image in a supervised manner revealing the distribution of the various sediment properties measured in the data. This paper deals with the choice of classes for each sediment property and the consequential accuracy assessment. The study shows the high sensitivity of classification accuracy on the threshold choices and recommends this finding to be considered in future classification of intertidal sediment.

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