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# HYPERSPECTRAL MAPPING OF DANISH STREAMS FROM UNMANNED AERIAL SYSTEMS

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## ABSTRACT:

Rivers and streams play a major role in the environment, as they support a high biodiversity, transport water, sediments and contaminants into the ocean and play a major role in climate change adaption. Few of the traditional monitoring tools used in the determination of ecological status can provide the spatio-temporal perspective on biodiversity loss and its consequences for ecosystem functioning that are urgently needed [1]. Novel indicators for quantifying modifications in ecological state are thus being sought after, where remote sensing technology has a key role to play. However, streams in Denmark, as well as many headwater streams globally, are too small to be resolved by satellites. The advent of cheap and reliable Unmanned Aerial Systems (UAS), together with new lightweight sensors opens up the possibility for efficient remote sensing from UAS, but sensor accuracy is typically lower than for satellite-borne sensors. In particular, optical hyperspectral remote sensing can be applied in streams to retrieve water properties such as chlorophyll-a concentration, CDOM concentration and turbidity [2], to classify streambed sediment and benthic vegetation phenotypes [2] and to derive stream bathymetry. Compared to land surfaces, hyperspectral remote sensing over water is more challenging: water reflectivity is very low (< 10%), so either the signal is low, or if the sensor integration time is adjusted, adjacent land surfaces are oversaturated. Water has less identifiable features than land surfaces, making the image mosaicking process into a georeferenced map difficult, which is based on common features. The sensor used for hyperspectral data acquisition on board of the UAV is a CUBERT FireflEYE S185, which has 138 spectral bands of 4 nm bandwidth between 450-1000 nm. However, it has a dynamic range limited to 12 bits, a low signal to noise ratio, a small field of view (FOV) (15 °) and a low spatial resolution (50 x 50 pixels). The small FOV and low resolution require a precise UAS navigation in order to acquire data from the target. To address these challenges, a radiometric calibration of the hyperspectral camera for low light conditions, such as those prevalent in Denmark most of the year, was conducted using an integration sphere and the calibration was validated in the field with an ASD spectroradiometer. A downwelling irradiance sensor was integrated with the data acquisition platform to guide the hyperspectral exposure time during changing light conditions and to enable data collection without radiometric ground control points. Hyperspectral image stitching and georeferencing was done with the software Agisoft Photoscan, with the addition of high-resolution RGB images for improved feature detection. These methods resulted in hyperspectral reflectance maps and narrow band indices maps of a 5 m wide and 250 m long stream stretch with a ground resolution of approx. 25 cm. This work is a step forward in developing a workflow for UAS hyperspectral imaging over freshwater ecosystems under low solar zenith angles and varying irradiance conditions.

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