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Opportunities for multi-directional hyperspectral satellite data to monitor vegetation structure on a regional scale

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To prevent future damage from flooding, floodplain areas along the river Rhine and Meuse in the Netherlands are enlarged to accommodate expected increased water discharges. Concomitantly, there are possibilities for ecological rehabilitation, as agricultural land will be transformed into new wetlands and other nature areas. Remote sensing is seen as an important tool to map and monitor the vegetation succession and the associated changes in plant traits. This information can on the hand be used to provide river managers with up-to-date information on hydraulic roughness values of the vegetation and potential effects on river discharge. On the other hand it allows the combination of regional scale remote sensing derived products with dynamic vegetation models to improve the simulation and evaluation of management strategies on the current and future biodiversity status of a floodplain ecosystem.

The objective of this study was to develop a methodology for monitoring the location and structure properties of plant functional types in a river floodplain ecosystem using satellite-based multi-directional hyperspectral data. In this study we used data from the CHRIS sensor onboard the PROBA satellite acquired in 2005 over the test site Millingerwaard, a river floodplain ecosystem along the river Waal in the Netherlands. CHRIS data are particularly suitable for mapping vegetation structure because of its high spatial resolution (∼17m2), spectral coverage (18 bands from 400 nm to 1050 nm) and angular sampling (5 viewing angles). Relevant vegetation structure properties such as leaf area index (LAI) and fractional cover (fCover) were quantified on a pixel-by-pixel basis by using the radiative transfer model FLIGHT that simulates canopy bidirectional reflectance by using Monte Carlo ray tracing. After classification of the angular images into eight major land use classes, for three main classified plant functional types “herbaceous”, “shrubs” and “forest”, LAI and fCover maps were computed through model inversion of the CHRIS data. All three vegetation classes were modeled as a turbid medium, the forest class was additionally modeled with an explicit 3D canopy geometry. Although physically simplified, the 1D modeling approach provided superior results compared to the 3D approach, probably due to the less extensive parameterization process. LAI and fCover maps were computed for the CHRIS viewing angles in nadir direction, backscattering direction (-36°) and forward scattering direction (+36°). The backscattering direction gave the best results, because it showed most variation in LAI and fCover values. In order to assess the quality of the inversion, the resulting vegetation structure maps were validated with in situ LAI measurements that were collected using hemispherical photography and TRAC measurements. In addition, LAI estimates derived from the airborne hyperspectral sensor HyMap were compared to the CHRIS derived LAI. As a next step it will be assessed whether the inferred structural maps can be related to hydromorphological and vegetation models and thereby leading to catchment-level water discharge capacity maps which can be used as input for modeling of future climate scenarios.