Retrieval of vegetation biochemical and biophysical parameters using radiative transfer models and RapidEye imageries in different biomes

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The spatial and temporal distribution of vegetation biochemical and biophysical parameters are used as important inputs in models quantifying the exchange of energy and matter between the land surface and the atmosphere. Among the many vegetation parameters, leaf area index (LAI) and chlorophyll are of prime importance as they provide vital info for biodiversity assessment and have been recognized as Essential Biodiversity Variables (EBVs). Significant efforts to estimate and quantify these parameters using Radiative Transfer Models (RTM) have been carried out in the last two decades. However, most of these studies are mainly benefited from using hyperspectral measurements. Although hyperspectral data have demonstrated to be accurate and suitable for retrieval of vegetation parameters, they are usually expensive and not frequently available. New generation of multispectral sensors with high spatial resolutions such as Sentinel-2 and RapidEye which provide spectral information at the red-edge region have provided further opportunities for estimating these parameters.

As part of the ESA: DUE, Innovators-III funded project RS4EBV (Remote Sensing for Essential Biodiversity Variables), in this study the retrieval of LAI and chlorophyll is investigated utilizing RapidEye images and different RTMs. Several RapidEye images were acquired between March and September 2015, for each of the three study sites of the project, i.e. 1) the Bavarian Forest National Park, 2) the National Park of Schiermonnikoog in the north of the Netherlands, and 3) the North Wyke Farm Platform in Devon, UK. In situ measurements of a large number of biophysical and biochemical

parameters including LAI and chlorophyll were collected during three distinct field campaigns concomitant with the time of image acquisitions in summer 2015.

Figure 1: The study sites.

The widely used canopy radiative transfer models: PROSAIL (SAILH and the PROSPECT) and INFORM (Invertible Forest Reflectance Model), were investigated for retrieval of LAI and chlorophyll in grasslands (including the saltmarsh) and forest study sites, respectively. The two RTMs were first parameterized based on the spectral band settings of RapidEye. Large look-up tables (LUTs) with 500,000 records were generated for each study sites accounting for available prior information related to the distribution and range of the vegetation parameters in each study site. The sensor viewing angle, the relative azimuth angle and the average sun zenith angle were adjusted based on the measured angles were observed in RapidEye metadata files, representing the geometry of the measurements. The LUTs were then inverted using the spectral reflectance obtained from the images. To assess the performance of the model inversion and analyze the suitability of the models, the normalized RMSE and R^2 between independent in situ measurements and estimated parameters were used.

Next, several parameters including the LAI, leaf chlorophyll and water content of the sites were mapped using the INFORM and PROSAIL model. Before producing the maps, The Rapid Eye image was used as input to the inversion process and maps of the predicted traits were retrieved using the best fitting spectra.

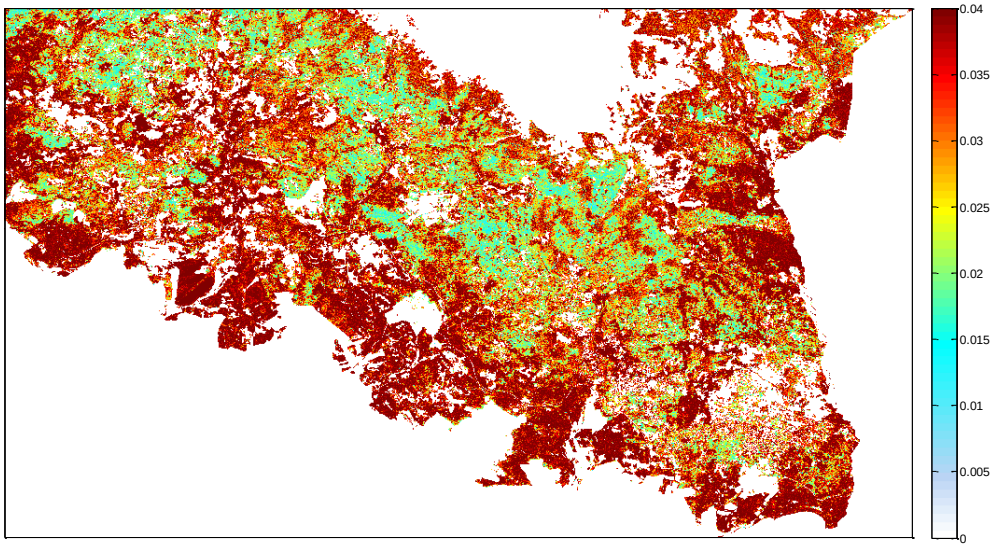

Figure 7: Map of foliar dry matter content (g cm^{-2}) for the Bavarian National Park, Germany from INFORM canopy reflectance model inversion using the RapidEye image of 17 July 2015.