German Remote Sensing Data Center
Land Surface Department

Laboratory for Essential Biodiversity Variables (EBV) Concepts – The "Data Pool Initiative for the Bohemian Forest Ecosystem"

U. Heiden, S. Holzwarth, N. Pinnel, A. Reichmuth, E. Raczko, M. Heurich, J. Müller, A. Skidmore, Z. Wang, A. Ali, T. Wang, R. Darvish, M. Wegmann

Developing Remote Sensing Based EBVs

Biophysical and biochemical vegetation parameters can characterize changes in biodiversity through changes in ecosystem structure and function. Acquisition of VIS/NIR hyperspectral, LiDAR, thermal and RADAR remote sensing data allow accurate retrieval of vegetation parameters (e.g., LAI, Chlorophyll, specific leaf area (SLA) , nitrogen, water content, species occurrence and 3D vegetation structural attributes) which have been recognized as **Essential Biodiversity Variables (EBV)** by GEO-BON - the Biodiversity Observation Network of GEO.

The Bohemian Forest Ecosystem is a perfect laboratory for studying biodiversity measures. Therefore, the idea was to establish a **Data Pool Initiative** to enable science for biodiversity and to support interdisciplinary and international projects and development.

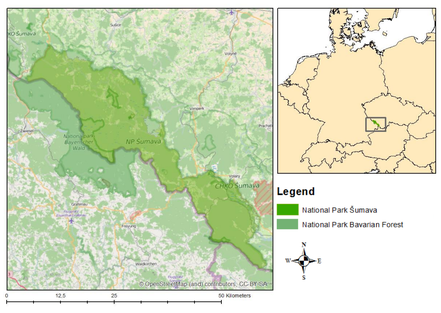

Figure 1: Location and size of the research site

The Bohemian Forest Ecosystem

The two neighboring National Parks Bavarian Forest and Šumava form a unique forest ecosystem with large non-intervention zones, which promote a large scale re-wilding process with low human interference. The parks provide important ecosystem services of clear water, carbon sequestration and recreation, and have fragile habitats with endangered forest species. The bohemian forest ecosystem is therefore a very suitable field of research to study natural and near natural processes. Under the leadership of the Bavarian Forest National Park authority, experts from various European research institutions have joined forces to systematically establish a remote sensing data pool on the Bohemian Forest as a resource for their research. This collaborative effort provides an opportunity to combine various methodological approaches as well as data sources to optimize products by sharing knowledge and expertise.

Content of the Data Pool

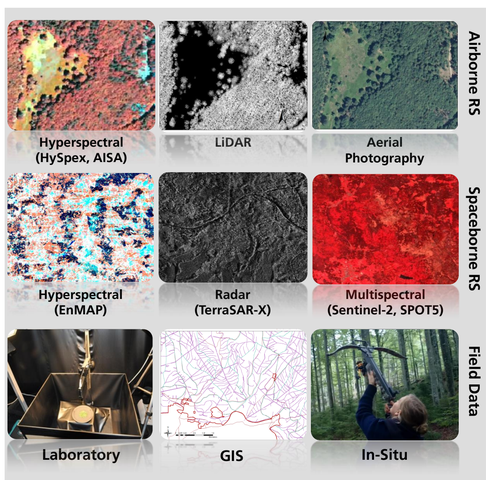

Figure 2: Different data available through the data pool

Derivation of Plant Traits

The estimation of two functional leaf traits leaf dry matter content (LDMC) and specific leaf area (SLA) is part of a PhD study within the Bavarian Forest National Park. First, the inversion of the PROSPECT radiative transfer model was applied to field spectra to estimate the leaf traits. Second, the leaf functional traits were retrieved from HySpex hyperspectral imagery using radiative transfer models and continuous wavelet analysis.

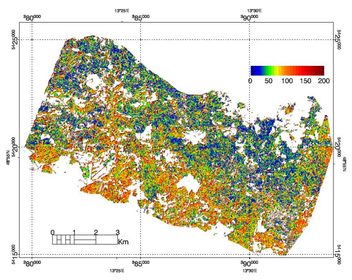

Figure 3: SLA in cm2/g maps derived from HySpex imagery

Abebe Mohammed Ali, R. Darvishzadeh, A. K. Skidmore, I. van Duren, U. Heiden, M. Heurich, Estimating leaf functional traits by inversion of PROSPECT: Assessing leaf dry matter content and specific leaf area in mixed mountainous forest, International Journal of Applied Earth Observation and Geoinformation, Volume 45, Part A, March 2016, Pages 66-76

Another experiment deals with the determination of leaf nitrogen derived from visible and SWIR imaging spectroscopy. For this purpose the canopy structure effects are decoupled from the remote sensing data using the DASF-transformation method. The narrowband absorption features of nitrogen are then characterized with a wavelet analysis.

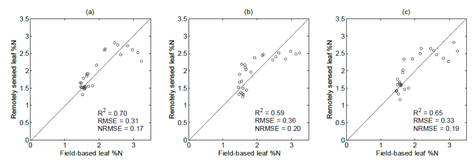

Figure 4: Comparison between field-based and remotely sensed leaf %N obtained by regression models using: (a) wavelet feature $WP_{1513,5}$ derived from canopy BRF, (b) wavelet feature $WP_{1591,4}$ derived from DASF-transformed spectra, (c) a combination of wavelet features $WP_{2005,8}$, $WP_{1507,5}$, $WP_{528,6}$ and $WP_{477,5}$ derived from DASF-transformed spectra.

Tree Species Classification

The development of advanced techniques for tree species mapping based on hyperspectral remote sensing in combination with other remote sensing and in-situ measurements is a major task within the data pool initiative. The different studies aim at building a model transferable to an area wide mapping of tree species based on the needs of the National Parks. First results show, that a tree species feature database consisting of hyperspectral signatures and relatively simple LiDAR derived features has high potential for a remote sensing based forest inventory.

Sommer, C., Holzwarth, S., Heiden, U., Heurich, M., Müller, J., Mauser, W. (2016). FEATURE BASED TREE SPECIES CLASSIFICATION USING HYPERSPECTRAL AND LIDAR DATA IN THE BAVARIAN FOREST NATIONAL PARK, EARSel eProceedings, Vol. 14, Special Issue 2: 9th EARSeL Imaging Spectroscopy Workshop, 2015

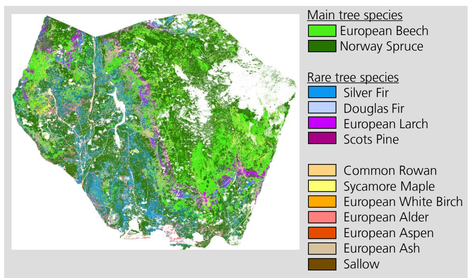

Figure 5: First result of tree species classification in the Bavarian Forest National Park

Monitoring of Deadwood Areas

A significant part of the National Parks is covered by deadwood. These areas are of great interest, since they are directly connected to a high biodiversity. This is also the reason for the National Park authorities of the Bavarian Forest to maintain and update a data base about deadwood since 1989 including the different management types of deadwood areas. The visualization of the evolution of deadwood areas over a long period of time can be realized with the help of different vegetation indices and LiDAR derived parameters. The results of the tree species classification can be used as input to determine the composition of tree species within the deadwood areas.

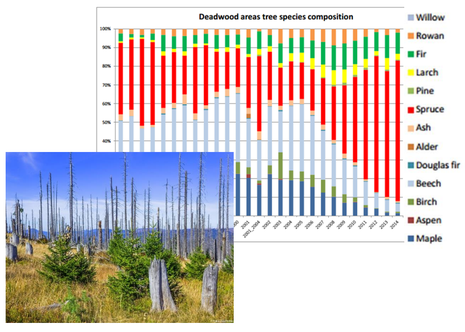

Figure 6: Tree species composition in deadwood areas

Outlook – Spaceborne Imaging Spectroscopy

With the support of both National Parks and with a comprehensive fine-scale EO and in-situ data base, EBV concepts using EO data of broader scale can be developed, tested and validated. These upscaling studies will foster the establishment of globally derived Essential Biodiversity Variables as currently pushed by the GEO BON and CEOS networks. One of the most promising technique is based on spaceborne imaging spectroscopy. There are several spaceborne initiatives and missions ongoing such as EnMAP - The German Environmental Mapping and Analysis Program. It will be a contributing mission to the Copernicus program. **EnMAP** is expected to provide high quality imaging spectroscopy data on an operational basis and will be suitable for the retrieval of high resolution plant traits at local scales. First studies within the data pool have been focused on e.g. derivation of plant traits like chlorophyll, LAI and nitrogen and tree species classification with a special focus on rare species within the national park, just to name a few. Moreover, the synergistic use of imaging spectroscopy mission and the **ESA's Sentinel** missions is in the focus of the data pool initiative.

EnMAP Hyperspectral Imager

Copernicus

Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Education and Training

It is foreseen to conduct a summer school in 2017 to educate and train the next-generation researchers in remote sensing for Essential Biodiversity Variables (EBV). A corresponding proposal called "RS4forestEBV" has been submitted to EUFAR ("European facility for Airborne Research") and is currently under review.

EUFAR

Nationalpark Bayerischer Wald · Šumava · Julius-Maximilians-Universität Würzburg · ITC University of Twente · Technische Universität München · Hochschule für angewandte Wissenschaften München