EnMAP Flight Campaigns

Technical Report

Döberitzer Heide 2008 / 2009
An EnMAP Preparatory Flight Campaign

Carsten Neumann, Gabriele Weiss, Sibylle Itzerott

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GFZ German Research Centre for Geosciences

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Table of Contents

Abstract

The dataset is composed of a) hyperspectral imagery acquired during airplane overflights on August 7th, 2008 and August 20th, 2009 consisting of 126 and 125 spectral bands, respectively, ranging from VIS to SWIR (456 - 2490 nm and 453 - 2480 nm) wavelength regions; b) spectral reference measurements acquired with an portable ASD field spectroradiometer in 2150 spectral bands (350 - 2500nm) in the same phenological periods of July/August/September 2008/09; c) plant species assemblages on 81 moist and 72 dry habitats consisting of the fractional cover of all vascular plants, mosses and lichens. The overall goal of the study was to map plant species shift along environmental gradients relating spectral information to the floristic composition. Reference plots of 1 or 2 m² size were thereby located in typical plant communities as well as in transition zones affected by species shift due to management measures such as grazing or shrub removal. In addition 17 field plots were analyzed with regard to soil horizon parameter (e.g. pH, grain size, carbonate content) in the year 2011. Soil types are further available on 51 core samples.

Coordinates:	**center:**	52.50 N / 13.03 E
	NW:	52.54 N / 12.96 E
	NE:	52.54 N / 13.11 E
	SE:	52.46 N / 13.11 E
	SW:	52.46 N / 12.96 E

Keywords: Hyperspectral Imagery, Field Spectroscopy, Plant Species Assemblages, Ecological Gradients

Related Work:

An overview of the EnMAP mission is provided in Guanter et al. (2015):

Guanter, L., Kaufmann, H., Segl, K., Foerster, S., Rogaß, C., Chabrillat, S., Küster, T., Hollstein, A., Rossner, G., Chlebek, C., Straif, C., Fischer, S., Schrader, S., Storch, T., Heiden, U., Mueller, A., Bachmann, M., Mühle, H., Müller, R., Habermeyer, M., Ohndorf, A., Hill, J., Buddenbaum, H., Hostert, P., van der Linden, S., Leitão, P., Rabe, A., Doerffer, R., Krasemann, H., Xi, H., Mauser, W., Hank, T., Locherer, M., Rast, M., Staenz, K., Sang, B. (2015): The EnMAP Spaceborne Imaging Spectroscopy Mission for Earth Observation. - Remote Sensing, 7, 7, p. 8830-8857, http://doi.org/10.3390/rs70708830.

The Scientific Technical Report STR 13/02 on the project "Monitoring in der Döberitzer Heide (Vegetation und Fernerkundung)" (Neumann et al, 2013) provides information about spectral and vegetation data processing, methodological approaches and final results including spatially explicit maps on floristic and faunistic habitat characteristics:

Neumann, C., Weiß, G., Itzerott, S., Kühling, M., Fürstenow, J., Luft, L., Nitschke, P. (2013): Entwicklung und Erprobung eines innovativen, naturschutzfachlichen Monitoringverfahrens auf der Basis von Fernerkundungsdaten am Beispiel der Döberitzer Heide, Brandenburg: Abschlussbericht, (Scientific Technical Report; 13/02), Potsdam : Deutsches GeoForschungsZentrum GFZ , http://doi.org/10.2312/GFZ.b103-13024.

Spectral discrimination potential was tested for different complexity levels of vegetation aggregation using spectral transformation techniques on image and field spectra. On that basis a spectral monitoring approach was developed that was published in Luft et al. (2014):

Luft, L., Neumann, C., Freude, M., Blaum, N., Jeltsch, F. (2014) Hyperspectral modeling of ecological indicators – A new approach for monitoring former military training areas. Ecological Indicators, Volume 46, November 2014, Pages 264–285, http://doi.org/10.1016/j.ecolind.2014.06.025

The dataset was used in Neumann et al (2015) and Siegmann et al. (2014):

Neumann, C., Weiss, G., Schmidtlein, S., Itzerott, S., Lausch, A., Doktor, D., & Brell, M. (2015). Gradient-Based Assessment of Habitat Quality for Spectral Ecosystem Monitoring. Remote Sensing, 7(3), 2871–2898. http://doi.org/10.3390/rs70302871.

Siegmann, B., Glässer, C., Itzerott, S., & Neumann, C. (2014). An Enhanced Classification Approach using Hyperspectral Image Data in Combination with in situ Spectral Measurements for the Mapping of Vegetation Communities. Photogrammetrie - Fernerkundung - Geoinformation, 2014(6), 523–533. http://doi.org/10.1127/pfg/2014/0243.

Field spectra, related sampling parameters, plant species assemblages as well as abiotic environmental parameter on field plot scale are made available in a database called SPECTATION (Spectral database for Vegetation): http://www.gfz-potsdam.de/spectation

1 Introduction

The Environmental Mapping and Analysis Program (EnMAP) is a German hyperspectral satellite mission that aims at monitoring and characterizing the Earth's environment on a global scale. EnMAP serves to measure and model key dynamic processes of the Earth's ecosystems by extracting geochemical, biochemical and biophysical parameters, which provide information on the status and evolution of various terrestrial and aquatic ecosystems. In the frame of the EnMAP preparatory phase, pre-flight campaigns including airborne and in-situ measurements in different environments and for several application fields are being conducted. The main purpose of these campaigns is to support the development of scientific applications for EnMAP. In addition, the acquired data are input in the EnMAP end-to-end simulation tool (EeteS) and are employed to test data pre-processing and calibration-validation methods. The campaign data are made freely available to the scientific community under a Creative Commons Attribution-ShareAlike 4.0 International License. An overview of all available data is provided in in the EnMAP Flight Campaigns Metadata Portal (http://www.enmap.org/?q=flightbeta).

Flight Campaign "Döberitzer Heide"

The study site is located on a former military training area, Döberitzer Heide, in the west of Berlin, Germany. As a result of long term military use, diverse openland assemblages have established on glacial moraine deposits. There, a small scale floristic variability is characterized by mosaics and interpenetration of xeric sand grasslands, dry heaths, wet meadows and pioneer woods that reflect important habitat structures for nature conservation. Consequently, the main area of 3946 ha is protected as Special Area of Conservation (SAC) within the European Natura 2000 network. Natural succession takes place in various patterns and different phases, just as a bundle of management activities is realized by "Sielmanns Naturlandschaften" in order to preserve valuable habitat qualities. For an area wide mapping of plant communities and management induced species shift along environmental gradients, hyperspectral imagery (HyMap) was acquired in the years 2008 and 2009 combined with comprehensive field surveys. Vegetation samples were collected on 1 and 2 m² plots including 81 moist and 72 dry openland habitats. Within different phenological stages, 25 hyperspectral reflectance signatures were collected for every field plot using a portable field spectroradiometer (ASD Inc., Boulder, CO). The main objective of the study was to generate stable models between plant species/habitat characteristics and spectral features that can be transferred to image spectra for mapping purpose.

2 Data Acquisition

Hyperspectral imagery was acquired during two flight campaigns operated by DLR using HyVista's imaging spectrometer HyMap on board of a Do 228 aircraft. In 2008 all reference field plots were covered whereas only two flight lines covering the main openland areas were acquired in 2009 (see Figure 1).

2.1 Campaign 1:

Time: August 7, 2008 start: 11:00:51 end: 11:21:10 (Universal Time)
Samples: 512
Bands: 126
Wavelengths: 455.6 – 2490.1 nm

Strip Number	Flight Altitude	Scan Frequency	Flight Heading	Solar Azimuth	Solar Zenith	Pixel Size	Lines
Döberitz_1	1965 m	15.5 Hz	360°	182°	36°	4 m	2046
Döberitz_2	1965 m	15.5 Hz	360°	174°	36°	4 m	2271
Döberitz_3	1960 m	15.5 Hz	180°	185°	36°	4 m	2638
Döberitz_4	1955 m	15.5 Hz	180°	179°	36°	4 m	2727

2.2 Campaign 2:

Time: August 20, 2009 start: 9:14:39 end: 9:30:20 (Universal Time)
Samples: 512
Bands: 125
Wavelengths: 453.7 – 2479.8 nm

Strip Number	Flight Altitude	Scan Frequency	Flight Heading	Solar Azimuth	Solar Zenith	Pixel Size	Lines
Döberitz_1	2182 m	14 Hz	359°	139.6°	46.2°	4 m	4155
Döberitz_2	2177 m	14 Hz	179°	142.8°	45.2°	4 m	4253

3 Data Processing and Products

3.1 Hyperspectral airborne data

Level 1[1]: At sensor radiance in µW / (cm² sr nm) converted from DN using laboratory radiometric calibration information and in-flight measurements of the on-board calibration lamp provided by HyVista.

Level 2 atm: three products are available: (a) top of the canopy reflectance [REF] after atmospheric correction using radiative transfer model developed by Guanter et al. (2007), (b) Savitzky-Golay smoothing on reflectance spectra [POL] and (c) empirical line post-calibration [ELI] using field spectra collected during overflight

Level 2 geo: Ortho-rectified reflectance data for (b) and (c) were derived on a parametric model using recorded altitude and flight path data (inertial measurement unit) in combination with a digital terrain model (DEM). Subsequently, the outer orientation was adjusted with ground control points sampled on a reference image.

[1] Data levels used here are out-dated and not in line with the future EnMAP data levels.

3.2 Simulated EnMAP data

Simulated EnMAP data for one flight line of the 2008 campaign were generated using the EnMAP end-to-end simulation software (Segl et al., 2012).

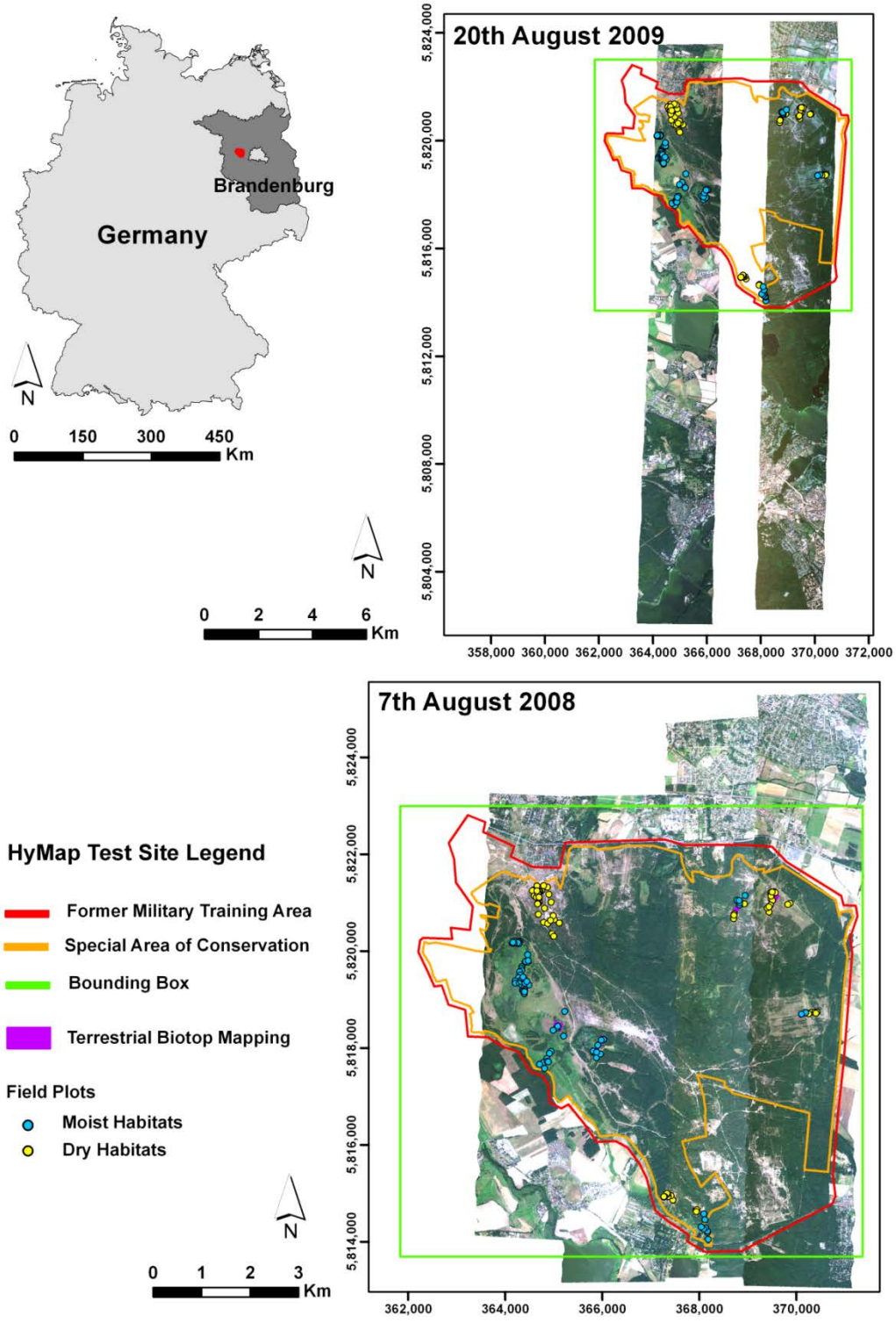

Figure 1: HyMap flight lines locations and covered field plots for terrestrial surveys of spectral reflectance and vegetation samples

4 File Description

4.1 File Format

Band Sequential Image File [*.bsq] and file header [*.hdr]

4.2 Data content and structure

Image files are described in the header file by the following attributes:
ENVI description, samples, lines, bands , header offset, file type, data type, interleave, sensor type, byte order, map info, wavelength units, band names, wavelength, fwhm

5 Data Quality/Accuracy

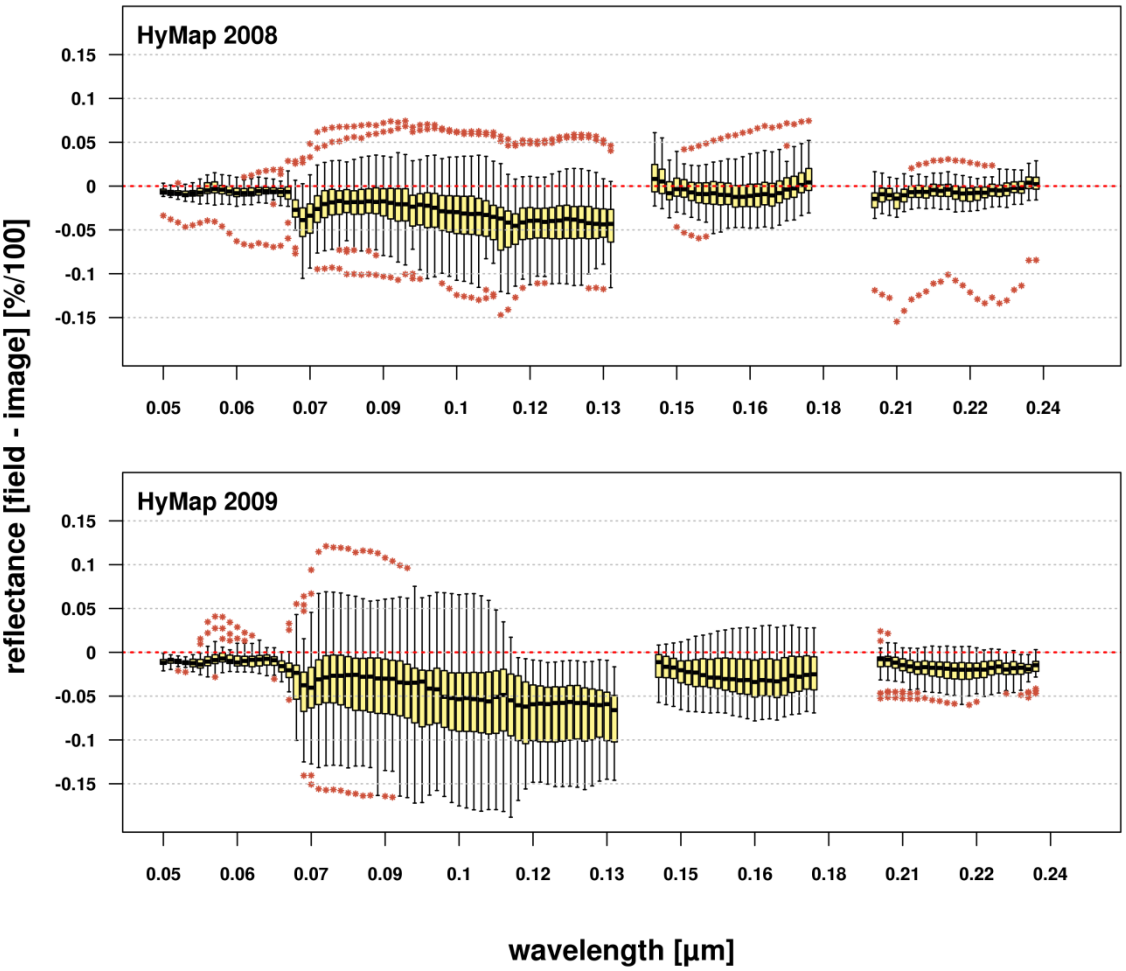

Figure 2: Wavelength specific Box-Whisker-Plots visualizing the differences of field spectra and atmospheric corrected HyMap image reflectance (product b) for n = 33 (2008) and n = 23 (2009) field plots acquired during overflights; red dots represent outliers that exceed ± 1.5 times the interquartile range (yellow box)

6 Additional Data

6.1 Additional GIS Data

A GIS data base was set up including maps, field data and additional environmental background information that were collected from past studies in the years from 1992 to 2011 grouped according the following categories[2].

GIS Data Category	Dataset Examples	Acquisition Time
Boundaries	conservation areas, animal fences, property and land use boundaries	2002 - 2009
Soil	general soil concept map	2010
Permanent Observation Plots	locations of continuously repeated vegetation plots, corner coordinates terrestrial vegetation sampling	2002 - 2009
Digital Terrain Model	1 – 25 meter elevation raster, digitized contour lines	2001 - 2009
Fauna	bird surveys (2002/2003), invertebrates traps (2008), bees, wasps, longhorn beetle surveys (2000), butterfly survey (2011)	2002 - 2011
Remote Sensing	CIR aerial images (1992, 2003, 2009), Quickbird/Worldview (2004, 2009, 2010), IRS (1999), Rapid Eye (2009-2011), Landsat (1987-2002), HyMap/AISA/APEX/Chris Proba (2008-2012)	1992-2012
Forest	hunting pulpits, hunting areas	2009
Buildings	buildings map	NA
Hydrology	Fenland mapping, EU-water framework areas	2007 - 2009
Vegetation Classification	SARA04 Vegetation maps based on Quickbird (2004) and Worldview (2010, 2011,2012), tree species map (2011)	2004 - 2012
Agriculture	Digitales Feldblockkataster	2009
Acidity	pH-value maps	2003/2011
Topographic maps	TK 10, TK25, TK 1903	1903/2000
Vegetation	Terrestrial biotop maps (2001, 2008, 2009), aerial image interpretations (2004, 2009)	2001 - 2009
Soil Transect Project	transect measurements of hydraulic conductivity, geoelectrics, infiltration rates etc., soil type model	2005 - 2006

6.2 Additional Spectral Field/ Lab Measurements

Spectral measurements were conducted with an ASD FieldSpec® Pro provided by Analytical Spectral Devices (ASD, Inc., Boulder, CO) that delivers relative reflectance values in relation to a white reference standard Spectralon®, provided by Labsphere, Inc., North Sutton, NH. Spectral reflectance values were recorded between 350 and 2500nm within spectral intervals resampled to 1nm wavelength units. Field plots are sampled with 25 single measurements starting from the South-West corner to

[2] These data will not be part of the data package, but may be provided upon request on a case-by-case decision depending on individual licence agreements.

the North-East corner in a 5 rows x 5 columns matrix (Figure 3). The aperture angle was set to φ = 8° with a constant height h = 1.4m over vegetation canopy, resulting in a sensor footprint diameter d = 0.2m. For every matrix element a reflectance curve was generated by averaging 50 single measurements under constant viewing geometry.

The data collection was divided into two projects using different sample area sizes and acquisition times (table 1).

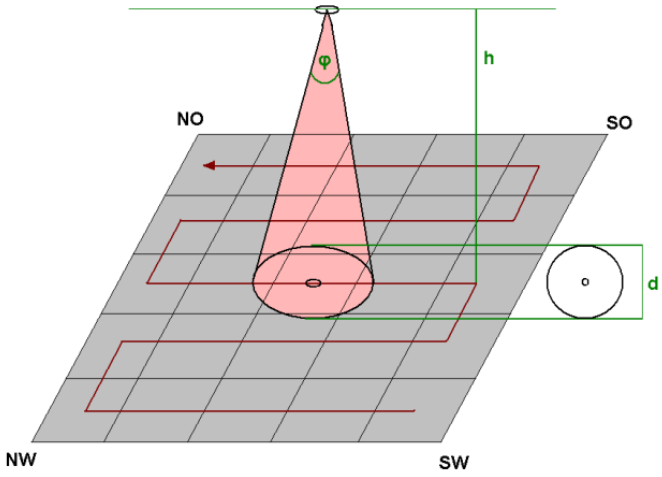

Figure 3: Sampling design for spectral field measurements on field plot scale

2008		2009	
2x2	1x1	2x2	1x1
28.05.	x	13.05.	x
30.05.	x	25.05.	x
02.06.	x	02.06.	02.06.
05.06.	x	17.06.	13.06.
09.06.	x	23.06.	17.06.
17.06.	x	02.07.	24.06.
24.06.	x	03.07.	03.07.
26.06.	x	27.07.	27.07.
02.07.	x	29.07.	29.07.
03.07.	x	31.07.	31.07.
24.07.	x	05.08.	05.08.
25.07.	x	06.08.	15.08.
28.07.	x	19.08.	19.08.
29.07.	x	20.08.	20.08.
31.07.	31.07.	24.08.	24.08.
07.08.	14.08.	01.09.	31.08.
09.09.	x	11.09.	01.09.
25.09.	x	05.10.	19.09.
26.09.	x	x	x

Table 1: ASD field spectral reflectance measurements for the two reference area sizes

6.3 Additional Field Data

Species abundances were estimated between 2007 and 2009 using the enhanced Braun-Blanquet method (Wilmanns, 1998) whereby species nomenclature is based on Rothmaler et al. (2005). The

fractional cover of all relevant vascular plant species, mosses, and lichens thus including all important habitats with typical transitions, succession states and pressure indicators were mapped. Additionally, the biotope type according Brandenburg key (Zimmermann, 2007), the Natura 2000 habitat type and related conservation status as well as the EUNIS habitat classification were mapped during terrestrial field campaigns for all field plots.

At the time of spectral measurements, supplementary data were collected for herb layer and shrub layer height, soil moisture, cloud cover and classification, weather conditions and acquisition time. For every plot, five pictures, one side view and four plan views for 1 x 1 or 0.5 x 0.5 m² areas, were taken. In the year 2011, soil horizons were described for 17 soil profiles close to selected field plots and 34 auger probes were collected for soil type identification.
Species assemblages, soil data and measurement logs are made available with tabular data files in excel *.xls and *.csv data formats for all field plots or allocated to specific plots in the spectral database SPECTATION.

6.4 Additional Laboratory Data

Soil horizons of 17 soil profiles were analysed in the laboratory according to the following parameters: dry and moist bulk density, root penetration, substance/pore/air/water volume, acidity, carbonate level, organic content, cation exchange capacity, base saturation, texture, grain size, Munsell color and field capacity.

7 Dataset Contact

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Rothmaler, W.; Jäger, E. J.; Werner, K. Exkursionsflora von Deutschland, 1 Gefäßpflanzen: Kritischer Band. 4th edition.; Elsevier: München, Germany, 2005.

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10 Appendix

10.1 List of field plots and related information

Area ID	E	N	Eleva-tion	Biotoptyp Brandenburg	Eunis Habitat	Corine LC
001a	364813	5817573	31.60	051122	E2.2	[321] Natural grassland
002a	364792	5817700	29.63	05101	E3.4	[322] Moors and heathland
003a	364709	5817662	32.18	05101	E3.4	[322] Moors and heathland
004a	364860	5817777	30.14	05101	E3.4	[322] Moors and heathland
005a	364864	5817727	30.45	05101	E3.4	[322] Moors and heathland
006a	364890	5817713	32.13	05101	E3.4	[322] Moors and heathland
007a	364950	5817928	31.84	05101	E3.4	[322] Moors and heathland
008a	364916	5817883	31.13	05101	E3.4	[322] Moors and heathland
009a	365227	5818754	43.82	0511311	E2	[321] Natural grassland
010a	364392	5819231	32.50	05102	E3.5	[322] Moors and heathland
011a	364359	5819196	32.50	05102	E3.5	[322] Moors and heathland
012a	364491	5819298	35.75	0511112	E2.1	[231] Pastures
013a	364394	5819121	32.79	05102	E3.5	[322] Moors and heathland
014a	365075	5818409	33.80	051121	E2.2	[321] Natural grassland
015a	365086	5818449	34.63	0511112	E2.1	[231] Pastures
016a	365204	5818246	33.72	051322	E2.1	[243] Land principally occupied by agriculture, with significant areas of natural vegetation
017a	364993	5818362	32.11	051121	E2.2	[321] Natural grassland
018a	365839	5817906	32.69	051121	E2.2	[321] Natural grassland
019a	365881	5817797	36.65	051121	E2.2	[321] Natural grassland
020a	366029	5818170	46.75	051321	E2.1	[243] Land principally occupied by agriculture, with significant areas of natural vegetation
021a	365965	5817874	46.15	051111	E2.1	[231] Pastures
022a	365817	5817933	33.00	03251	E5.1	[321] Natural grassland
023a	365884	5817908	34.25	051121	E2.2	[321] Natural grassland
024a	365913	5818053	33.25	051121	E2.2	[321] Natural grassland
025a	365981	5818159	34.79	051321	E2.1	[243] Land principally occupied by agriculture, with significant areas of natural vegetation
026a	368906	5820982	35.09	05142	E5.4	[322] Moors and heathland
027a	368929	5820975	38.57	05142	E5.4	[322] Moors and heathland
028a	368708	5820668	39.67	05121002	E1	[321] Natural grassland
029a	368724	5820771	37.95	05121002	E1	[321] Natural grassland
030a	368716	5820738	39.03	05121002	E1	[321] Natural grassland
031a	368833	5820952	36.62	04510	D1.1	[322] Moors and heathland
032a	368835	5820998	34.97	04510	D1.1	[322] Moors and heathland
033a	368776	5821050	37.74	04510	D1.1	[322] Moors and heathland
034a	368824	5821043	35.10	04510	D1.1	[322] Moors and heathland
035a	368946	5821145	38.84	08103	G1.5	[321] Natural grassland
036a	369876	5820984	41.03	032001	E5.1	[321] Natural grassland

037a	369830	5820964	42.01	032001	E5.1	[321] Natural grassland
038a	369470	5821200	38.12	032001	E5.1	[321] Natural grassland
039a	369496	5821192	45.30	032001	E5.1	[321] Natural grassland
040a	369483	5821077	41.45	032001	E5.1	[321] Natural grassland
041a	369513	5821043	45.08	032001	E5.1	[321] Natural grassland
042a	369467	5820947	42.83	032001	E5.1	[321] Natural grassland
043a	369440	5820804	40.01	0610202	F4.2	[322] Moors and heathland
044a	369404	5820887	39.91	032001	E5.1	[321] Natural grassland
045a	369482	5821132	42.15	032001	E5.1	[321] Natural grassland
046a	369548	5821225	38.45	032001	E5.1	[321] Natural grassland
047a	369564	5821199	46.75	032001	E5.1	[321] Natural grassland
048a	370309	5818732	39.86	032001	E5.1	[321] Natural grassland
049a	370391	5818737	40.73	032001	E5.1	[321] Natural grassland
050a	370429	5818741	41.26	032001	E5.1	[321] Natural grassland
051a	370405	5818714	43.05	032001	E5.1	[321] Natural grassland
052a	370259	5818705	43.74	0610201	F4.2	[322] Moors and heathland
053a	370200	5818726	37.84	0610201	F4.2	[322] Moors and heathland
054a	370111	5818696	42.32	0610201	F4.2	[322] Moors and heathland
055a	364759	5821246	47.11	0610202	F4.2	[322] Moors and heathland
056a	364791	5820588	47.68	0610202	F4.2	[322] Moors and heathland
070a	364654	5821346	45.90	032001	E5.1	[321] Natural grassland
071a	364579	5821262	46.49	032001	E5.1	[321] Natural grassland
072a	364563	5821248	41.28	032001	E5.1	[321] Natural grassland
073a	364601	5821138	36.52	032001	E5.1	[321] Natural grassland
074a	364722	5821223	46.53	0610202	F4.2	[322] Moors and heathland
075a	364709	5821221	46.55	0610202	F4.2	[322] Moors and heathland
076a	364695	5821199	46.15	0610202	F4.2	[322] Moors and heathland
077a	364687	5821175	45.74	0610202	F4.2	[322] Moors and heathland
078a	364694	5821111	44.97	032001	E5.1	[321] Natural grassland
079a	364698	5821054	44.02	032001	E5.1	[321] Natural grassland
080a	364704	5821005	44.08	032001	E5.1	[321] Natural grassland
081a	364688	5820758	37.44	0610202	F4.2	[322] Moors and heathland
082a	364814	5820886	43.82	0610202	F4.2	[322] Moors and heathland
083a	364947	5821011	38.98	0610202	F4.2	[322] Moors and heathland
084a	364901	5821170	39.83	0610202	F4.2	[322] Moors and heathland
085a	364869	5821321	39.18	032001	E5.1	[321] Natural grassland
086a	364794	5821350	48.21	032001	E5.1	[321] Natural grassland
087a	364344	5819677	32.50	05102	E3.5	[322] Moors and heathland
088a	364337	5819638	32.50	05102	E3.5	[322] Moors and heathland
089a	364347	5819595	32.50	05102	E3.5	[322] Moors and heathland
090a	364298	5819570	32.49	05102	E3.5	[322] Moors and heathland
091a	364317	5819507	32.50	05102	E3.5	[322] Moors and heathland
092a	364299	5819428	32.50	05102	E3.5	[322] Moors and heathland
093a	364275	5819452	32.50	05102	E3.5	[322] Moors and heathland
094a	364282	5819356	32.50	05102	E3.5	[322] Moors and heathland
095a	364232	5819374	32.50	05102	E3.5	[322] Moors and heathland
096a	364207	5819382	34.69	04511	D1.1	[322] Moors and heathland

098a	364215	5819334	32.25	05102	E3.5	[322] Moors and heathland
099a	364295	5819334	32.50	05102	E3.5	[322] Moors and heathland
100a	364346	5819294	32.50	05102	E3.5	[322] Moors and heathland
101a	364392	5819249	32.50	05102	E3.5	[322] Moors and heathland
102a	364402	5819195	32.50	05102	E3.5	[322] Moors and heathland
103a	364374	5819170	32.50	05102	E3.5	[322] Moors and heathland
104a	364330	5819375	32.50	051121	E2.2	[321] Natural grassland
105a	364351	5819429	32.50	051121	E2.2	[321] Natural grassland
106a	364389	5819427	32.50	0511112	E2.1	[231] Pastures
107a	364367	5819463	32.51	0511112	E2.1	[231] Pastures
108a	364412	5819334	32.50	0511112	E2.1	[231] Pastures
109a	364449	5819375	32.78	0511112	E2.1	[231] Pastures
110a	368185	5814045	54.04	05142	E5.4	[322] Moors and heathland
111a	368175	5814189	53.04	05141	E5.4	[322] Moors and heathland
112a	368165	5814218	57.05	05141	E5.4	[322] Moors and heathland
113a	368133	5814286	42.86	05142	E5.4	[322] Moors and heathland
114a	368087	5814260	30.20	032002	E5.1	[321] Natural grassland
115a	368088	5814327	33.36	05142	E5.4	[322] Moors and heathland
116a	368040	5814304	31.09	032002	E5.1	[321] Natural grassland
117a	368121	5814450	50.44	083149	G4.F	[324] Transitional woodland-shrub
118a	368096	5814573	47.70	05121001	E1	[321] Natural grassland
119a	367937	5814650	44.07	032002	E5.1	[321] Natural grassland
120a	367954	5814661	53.14	032002	E5.1	[321] Natural grassland
121a	367943	5814621	33.88	032002	E5.1	[321] Natural grassland
123a	367459	5814861	38.92	032002	E5.1	[321] Natural grassland
124a	367445	5814880	47.17	032002	E5.1	[321] Natural grassland
125a	367420	5814948	57.82	05121002	E1	[321] Natural grassland
126a	367364	5814932	42.05	032002	E5.1	[321] Natural grassland
127a	367352	5814981	49.08	05121002	E1	[321] Natural grassland
128a	367340	5814995	46.21	05121002	E1	[321] Natural grassland
129a	367290	5814929	40.08	032002	E5.1	[321] Natural grassland
130a	367269	5814918	30.84	032002	E5.1	[321] Natural grassland
131a	367269	5814929	32.07	032002	E5.1	[321] Natural grassland
132a	364296	5820200	35.73	0510101	E3.4	[322] Moors and heathland
133a	364274	5820195	33.13	0510101	E3.4	[322] Moors and heathland
134a	364219	5820196	39.50	0510101	E3.4	[322] Moors and heathland
135a	364264	5820155	32.50	0510101	E3.4	[322] Moors and heathland
136a	364285	5820153	32.58	0510101	E3.4	[322] Moors and heathland
137a	364265	5820174	32.45	0510101	E3.4	[322] Moors and heathland
138a	364184	5820160	32.48	0510101	E3.4	[322] Moors and heathland
139a	364148	5820162	34.75	0510101	E3.4	[322] Moors and heathland
140a	364163	5820179	37.10	0510101	E3.4	[322] Moors and heathland
141a	364472	5819773	38.47	0511211	E2.2	[321] Natural grassland
142a	364413	5819770	32.50	0510311	E3.4	[322] Moors and heathland
143a	364422	5819782	32.45	0510311	E3.4	[322] Moors and heathland
144a	364475	5819802	39.44	0511211	E2.2	[321] Natural grassland

145a	364463	5819920	38.78	0511211	E2.2	[321] Natural grassland
146a	364644	5821110	42.80	032001	E5.1	[321] Natural grassland
147a	364672	5821192	45.60	0610202	F4.2	[322] Moors and heathland
148a	364668	5821193	45.40	0610202	F4.2	[322] Moors and heathland
149a	364674	5821191	45.70	0610202	F4.2	[322] Moors and heathland
150a	364659	5821244	46.21	032001	E5.1	[321] Natural grassland
151a	364677	5820985	42.15	0610202	F4.2	[322] Moors and heathland
152a	364680	5820986	42.65	0610202	F4.2	[322] Moors and heathland
153a	364670	5820976	37.73	0610202	F4.2	[322] Moors and heathland
154a	364401	5819159	32.79	05102	E3.5	[322] Moors and heathland
155a	369569	5821204	45.47	032001	E5.1	[321] Natural grassland
156a	369507	5821217	39.53	032001	E5.1	[321] Natural grassland
157a	369438	5820911	40.95	032001	E5.1	[321] Natural grassland
158a	364698	5821107	44.90	032001	E5.1	[321] Natural grassland
159a	364701	5821109	45.44	032001	E5.1	[321] Natural grassland
170a	365115	5820581	39.48	0610202	F4.2	[322] Moors and heathland
171a	365014	5820651	50.02	032001	E5.1	[321] Natural grassland
172a	364992	5820726	47.55	05120001	E1	[321] Natural grassland
173a	364876	5820569	50.66	032001	E5.1	[321] Natural grassland
174a	364964	5820358	55.19	083609	G4.F	[324] Transitional woodland-shrub
175a	365001	5820305	53.30	083609	G4.F	[324] Transitional woodland-shrub
176a	364935	5820633	49.30	032001	E5.1	[321] Natural grassland

10.2 List of available datasets

HyMap09

Filename	Extension	Format	Size	Content
090820_Doeberitz_01_rad	*.bsq	ENVI Band sequential Image data	519 MB	At sensor radiance in µW / (cm² sr nm) flight strip 1
090820_Doeberitz_01_rad	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
090820_Doeberitz_02_rad	*.bsq	ENVI Band sequential Image data	531 MB	At sensor radiance in µW / (cm² sr nm) flight strip 2
090820_Doeberitz_02_rad	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
090820_Doeberitz_01_REFL	*.bsq	ENVI Band sequential Image data	519 MB	At canopy reflectance in %·100 flight strip 1
090820_Doeberitz_01_REFL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
090820_Doeberitz_02_REFL	*.bsq	ENVI Band sequential Image data	531 MB	At canopy reflectance in %·100 flight strip 2
090820_Doeberitz_02_REFL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
090820_Doeberitz_01_REFL_POL	*.bsq	ENVI Band sequential Image data	519 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, flight strip 1
090820_Doeberitz_01_REFL_POL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
090820_Doeberitz_02_REFL_POL	*.bsq	ENVI Band sequential Image data	531 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, flight strip 2
090820_Doeberitz_02_REFL_POL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
090820_Doeberitz_01_REFL_POL_Geo	*.bsq	ENVI Band sequential Image data	1042 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, geometrically corrected flight strip 1
090820_Doeberitz_01_REFL_POL_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
090820_Doeberitz_02_REFL_POL_Geo	*.bsq	ENVI Band sequential Image data	1056 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, geometrically corrected flight strip 2
090820_Doeberitz_02_REFL_POL_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
090820_Doeberitz_01_REFL_POL_Eli	*.bsq	ENVI Band sequential Image data	1039 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra flight strip 1
090820_Doeberitz_01_REFL_POL_Eli	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
090820_Doeberitz_02_REFL_POL_Eli	*.bsq	ENVI Band sequential Image data	1063 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra flight strip 2
090820_Doeberitz_02_REFL_POL_Eli	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
090820_Doeberitz_01_REFL_POL_Eli_Geo	*.bsq	ENVI Band sequential Image data	2332 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra, geometrically corrected flight strip 1
090820_Doeberitz_01_REFL_POL_Eli_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
090820_Doeberitz_02_REFL_POL_Eli_Geo	*.bsq	ENVI Band sequential Image data	2338 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra, geometrically corrected flight strip 2
090820_Doeberitz_02_REFL_POL_Eli_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
090820_Doeberitz_01_convert	*.txt	Textfile tab-separated	528 kB	Inertial Measurement Unit orientation parameter strip 1
090820_Doeberitz_02_convert	*.txt	Textfile tab-separated	637 kB	Inertial Measurement Unit orientation parameter strip 2
2009HyEurope_CRT_doeberitz	*.pdf	Adobe Portable Document Format	350 kB	Technical campaign report

HyMap08

Filename	Extension	Format	Size	Content
080807_Doeberitz_01_rad	*.bsq	ENVI Band sequential Image data	258 MB	At sensor radiance in µW / (cm² sr nm) flight strip 1
080807_Doeberitz_01_rad	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
080807_Doeberitz_02_rad	*.bsq	ENVI Band sequential Image data	286 MB	At sensor radiance in µW / (cm² sr nm) flight strip 2
080807_Doeberitz_02_rad	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
080807_Doeberitz_03_rad	*.bsq	ENVI Band sequential Image data	332 MB	At sensor radiance in µW / (cm² sr nm) flight strip 3
080807_Doeberitz_03_rad	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 3
080807_Doeberitz_04_rad	*.bsq	ENVI Band sequential Image data	344 MB	At sensor radiance in µW / (cm² sr nm) flight strip 4
080807_Doeberitz_04_rad	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 4
080807_Doeberitz_01_REFL	*.bsq	ENVI Band sequential Image data	258 MB	At canopy reflectance in %·100 flight strip 1
080807_Doeberitz_01_REFL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
080807_Doeberitz_02_REFL	*.bsq	ENVI Band sequential Image data	286 MB	At canopy reflectance in %·100 flight strip 2
080807_Doeberitz_02_REFL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
080807_Doeberitz_03_REFL	*.bsq	ENVI Band sequential Image data	332 MB	At canopy reflectance in %·100 flight strip 3
080807_Doeberitz_03_REFL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 3
080807_Doeberitz_04_REFL	*.bsq	ENVI Band sequential Image data	344 MB	At canopy reflectance in %·100 flight strip 4
080807_Doeberitz_04_REFL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 4
080807_Doeberitz_01_REFL_POL	*.bsq	ENVI Band sequential Image data	258 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, flight strip 1
080807_Doeberitz_01_REFL_POL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
080807_Doeberitz_02_REFL_POL	*.bsq	ENVI Band sequential Image data	286 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, flight strip 2
080807_Doeberitz_02_REFL_POL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
080807_Doeberitz_03_REFL_POL	*.bsq	ENVI Band sequential Image data	332 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, flight strip 3
080807_Doeberitz_03_REFL_POL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 3
080807_Doeberitz_04_REFL_POL	*.bsq	ENVI Band sequential Image data	344 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, flight strip 4
080807_Doeberitz_04_REFL_POL	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 4
080807_Doeberitz_01_REFL_POL_Geo	*.bsq	ENVI Band sequential Image data	3683 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, geometrically corrected flight strip 1
080807_Doeberitz_01_REFL_POL_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
080807_Doeberitz_02_REFL_POL_Geo	*.bsq	ENVI Band sequential Image data	4181 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, geometrically corrected flight strip 2
080807_Doeberitz_02_REFL_POL_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
080807_Doeberitz_03_REFL_POL_Geo	*.bsq	ENVI Band sequential Image data	4682 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, geometrically corrected flight strip 3
080807_Doeberitz_03_REFL_POL_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 3
080807_Doeberitz_04_REFL_POL_Geo	*.bsq	ENVI Band sequential Image data	5046 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, geometrically corrected flight strip 4
080807_Doeberitz_04_REFL_POL_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 4

Filename	Extension	Format	Size	Content
080807_Doeberitz_01_REFL_POL_Eli	*.bsq	ENVI Band sequential Image data	258 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra flight strip 1
080807_Doeberitz_01_REFL_POL_Eli	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
080807_Doeberitz_02_REFL_POL_Eli	*.bsq	ENVI Band sequential Image data	286 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra flight strip 2
080807_Doeberitz_02_REFL_POL_Eli	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
080807_Doeberitz_03_REFL_POL_Eli	*.bsq	ENVI Band sequential Image data	332 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra flight strip 3
080807_Doeberitz_03_REFL_POL_Eli	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 3
080807_Doeberitz_04_REFL_POL_Eli	*.bsq	ENVI Band sequential Image data	344 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra flight strip 4
080807_Doeberitz_04_REFL_POL_Eli	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 4
080807_Doeberitz_01_REFL_POL_Eli_Geo	*.bsq	ENVI Band sequential Image data	867 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra, geometrically corrected flight strip 1
080807_Doeberitz_01_REFL_POL_Eli_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 1
080807_Doeberitz_02_REFL_POL_Eli_Geo	*.bsq	ENVI Band sequential Image data	952 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra, geometrically corrected flight strip 2
080807_Doeberitz_02_REFL_POL_Eli_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 2
080807_Doeberitz_03_REFL_POL_Eli_Geo	*.bsq	ENVI Band sequential Image data	1122 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra, geometrically corrected flight strip 3
080807_Doeberitz_03_REFL_POL_Eli_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 3
080807_Doeberitz_04_REFL_POL_Eli_Geo	*.bsq	ENVI Band sequential Image data	1158 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, Empirical Line Correction with field reference spectra, geometrically corrected flight strip 4
080807_Doeberitz_04_REFL_POL_Eli_Geo	*.hdr	ENVI Header-File	4 kB	Metadata flight strip 4
080807_Doeberitz_01_REFL_POL_Geo_enmap	*.bsq	ENVI Band sequential Image data	29 MB	At canopy reflectance in %·100, Savitzky-Golay-Filtered, geometrically corrected, EeteS-simulated EnMAP flight strip 1
080807_Doeberitz_01_REFL_POL_Geo_enmap	*.hdr	ENVI Header-File	3 kB	Metadata flight strip 1
080807_Doeberitz_01_convert	*.txt	Textfile tab-separated	361 kB	Inertial Measurement Unit orientation parameter strip 1
080807_Doeberitz_02_convert	*.txt	Textfile tab-separated	377 kB	Inertial Measurement Unit orientation parameter strip 2
080807_Doeberitz_03_convert	*.txt	Textfile tab-separated	441 kB	Inertial Measurement Unit orientation parameter strip 3
080807_Doeberitz_04_convert	*.txt	Textfile tab-separated	452 kB	Inertial Measurement Unit orientation parameter strip 4
2008HyEurope_CRT_doeberitz	*.pdf	Adobe Portable Document Format	323 kB	Technical campaign report

FieldSpectra

Filename	Extension	Format	Size	Content
Reference_2008	*.esl	Envi Spectral Library	3966 kB	Bright and dark reflectance targets for Eli calibration
Reference_2008	*.hdr	ENVI Header-File	35 kB	Metadata reference spectra
FieldSpecHyMap08	*.esl	Envi Spectral Library	381 kB	At canopy reflectance for n = 33 vegetation sample plots collected near overflight time; resampled to HyMap 2008 spectral resolution
FieldSpecHyMap08	*.hdr	ENVI Header-File	17 kB	Metadata vegetation spectra
FieldPhotos08	folder content [*.jpg]	JPEG compression digital image	85 MB	Sample plot images taken from a 45° degrees perspective
Reference_2009	*.esl	Envi Spectral Library	2521 kB	Bright and dark reflectance targets for Eli calibration
Reference_2009	*.hdr	ENVI Header-File	32 kB	Metadata reference spectra
FieldSpecHyMap09	*.esl	Envi Spectral Library	338 kB	At canopy reflectance for n = 29 vegetation sample plots collected near overflight time; resampled to HyMap 2009 spectral resolution
FieldSpecHyMap09	*.hdr	ENVI Header-File	16 kB	Metadata vegetation spectra
FieldPhotos09	folder content [*.jpg]	JPEG compression digital image	66 MB	Sample plot images taken from a 45° degrees perspective
Reference_report	*.xls	Microsoft Excel Spreadsheet	25kB	Metadata for spectral libraries

Vegetation Samples

Filename	Extension	Format	Size	Content
Vegetation sampling	*.xls	Microsoft Excel Spreadsheet	230 kB	2 data sheets containing field plots of moist habitats and dry habitats
Vegetation samplingMoist	*.csv	Comma separated plain text	17 kB	Vegetation samples on moist habitats
Vegetation samplingDry	*.csv	Comma separated plain text	77 kB	Vegetation samples on dry habitats

Fields	Description
Area_ID	ID used for plot information
Natura 2000 Habitat Type	Habitat Type Number
Natura 2000 Habitat Type Assessment	Conservation Status (A-C)
Bare Soil Cover	absolute percent cover
Litter Cover	absolute percent cover
Scrub Cover	absolute percent cover
Grass Cover	absolute percent cover
Herb Cover	absolute percent cover
Species List	absolute percent cover

Soil Samples

Filename	Extension	Format	Size	Content
SoilProfiles	*.xls	Microsoft Excel Spreadsheet	142 kB	Laboratory analysis data for n = 17 soil profiles
CoordinatesSoilHori-zons	*.xls	Microsoft Excel Spreadsheet	41 kB	Coordinates of soil profiles
SoilProbes	*.xls	Microsoft Excel Spreadsheet	42 kB	Soil horizon depth for n = 34 auger probes

Fields SoilProfiles.xls
ID/Soil Horizons
Horizon upper/lower limits [cm]
Moist Density [g/cm³]
Dry Density [g/cm³]
Substance Density [g/cm³]
Substance Volume [Vol.-%]
Pore Volume [Vol.-%]
Air Volume [Vol.-%]
Water Volume [Vol.-%]
pH-value
Loss on Ignition 1 (%)
Loss on Ignition 2 (%)
Loss on Ignition 3 (%)
Loss on Ignition 4 (%)
Avergage C_{org} (1 + 2) (%)
Avergage C_{org} (3 + 4) (%)
Residue on Ignition/mineral amount (%)
S - value (cmol/kg)
H - value (cmol/kg)
T - value (= KAK(eff)) (cmol/kg)
effective Cation Exchange Capacity (KAK(eff)) (cmol/kg)
potential Cation Exchange Capacity (KAK(pot)) (cmol/kg)
V - value(Base Enrichment) (%)
Gravel Proportion (%)
Soil Color (Munsell)
Sand Proportion (%)
Silt Proportion (%)
Clay Proportion (%)
Field Capacity (FK) (Vol.%)
usable Field Capacity(nFK) (Vol.%)
Air Capacity (LK) (Vol.-%)
effective Rooting Depth (We) (dm)