EnMAP
Hyperspectral Imager

EnMAP
Technical Report

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Flight campaigns of the "EnMAP Data
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1 Abstract

Hyperspectral airborne campaigns have been carried out in the frame of the data exploitation and application development program of the German Environmental Mapping and Analysis Program (EnMAP) to support method and application development in the prelaunch phase of the EnMAP satellite mission. A metadata portal (EnMAP Campaign Portal) has been set up providing general information about the campaigns, recorded airborne hyperspectral data sets, other data associated to the respective campaigns like field and laboratory measurements and a number of field guides for in-situ data acquisition. Furthermore, it informs about the availability of simulated EnMAP and Sentinel-2 data for the respective campaign region. The data listed in the EnMAP Campaign Portal is freely available under a Creative Commons License as DOI-referenced data publications.

Keywords: EnMAP, airborne, in-situ, metadata, digital object identifier, dataset DOI

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.

2 Introduction

The Environmental Mapping and Analysis Program (EnMAP) is a German hyperspectral satellite mission that aims at monitoring and characterizing the Earth's surface and environmental changes (Guanter et al. 2015). 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 status and evolution of various terrestrial and aquatic ecosystems. Therefore, EnMAP satellite data will provide valuable information for understanding the complexity of the Earth's system and to study the effect of man-made interventions in ecosystems. Such information will support scientists, national authorities and stakeholders to understand fundamental environmental mechanisms contributing to social challenges.

The upcoming EnMAP mission will operate a new space-borne imaging spectrometer, HSI - Hyperspectral Imager, with an expected high data quality. EnMAP will record data over the large spectral range from the visible and near infrared (VNIR) to the shortwave infrared (SWIR) comprising more than 240 adjacent spectral bands. Such imaging spectroscopy data allow the direct identification and quantification of material of the Earth's surface. The revisit time of the satellite will be 27 days (at nadir) with a ground sampling distance of 30 m. The full VNIR/SWIR wavelength range together with the extensive spatial coverage of 900 km^2 per scene opens ways for new applications. An important step towards the operational use of EnMAP data is the upscaling of existing imaging spectroscopy approaches developed for airborne data with limited spatial coverage. However, a direct transfer of these methods to spaceborne imaging spectroscopy data will be challenging because of, e.g. the different spatial resolutions or orbit characteristics. Therefore, new or adapted methods will be required to exploit the full information content of the EnMAP HSI data.

To stimulate the process of new developments, the "EnMAP Data Exploitation and Application Development Program" has been implemented in the prelaunch phase of the EnMAP mission. Its purpose is to build up a network of national and international researchers developing techniques for spaceborne hyperspectral image analyses for a wide range of disciplines and application fields. For the development of new and the adaption of existing methods high quality hyperspectral airborne data is needed. One important element of the "EnMAP Data Exploitation and Application Development Program" is the organization and implementation of flight campaigns that comprise hyperspectral flight surveys accompanied with other data acquisition such as in-situ and laboratory measurements in different environments and for several application fields (Weide et al., 2010). The main objectives of these flight campaigns are:

- to support the development and adaption of advanced scientific algorithms and methods in a wide range of applications using EnMAP data
- to create test data for optimizing pre- and post-processing algorithms
- to develop suitable calibration and validation methods
- to provide simulated EnMAP data for spatial and spectral upscaling studies using the EnMAP end-to-end simulation tool (EeteS, Segl et al. 2012).

An important aspect of the "EnMAP Data Exploitation and Application Development Program" is to enlarge the ability for data exchange and reusability for other researchers. However, airborne campaigns have been carried out by different providers, with different sensor systems and data are processed using different pre-processing chains. Furthermore, accompanying field surveys are in the

responsibility of different researchers participating in the "EnMAP Data Exploitation and Application Development Program" and thus, are conducted with various field instrumentations and techniques.

To enlarge the ability for data exchange and reusability for a wide range of researchers, geospatial platforms have been developed in the past years. Examples are large national platforms such as TEODOOR, the Data Discovery Portal of the Terrestrial Environmental Observatories (TEODOOR, 2016), and international data platforms such as Earth Observing System Data and Information System (EOSDIS) as key core capability in NASA's Earth Science Data Systems Program (EOSDIS, 2016). The Terrestrial Ecosystem Research Network (TERN) connects ecosystem scientists and enables them to collect, contribute, store, share and integrate data across disciplines in Australia (TERN, 2016). NASA/JPL also runs the AVIRIS Data Portal (AVIRIS Data Portal, 2016), that specifically enables data access to airborne hyperspectral AVIRIS data products, calibration and validation information, publications, etc. The latter is comparable to the EnMAP Campaign Portal that has been developed to provide a standardized and common knowledge base and informs interested researchers about the specification and availability of hyperspectral airborne and all additional data acquired during an EnMAP flight campaign.

All data acquired during the "EnMAP Data Exploitation and Application Development Program" are made freely available to the scientific community under a Creative Commons Attribution-Share Alike 4.0 International License. Since 2015 EnMAP flight campaign data packages are successively published as DOI-referenced data publications by GFZ Data Services (e.g. Neumann et al., 2015a) hosted at GFZ German Research Centre for Geosciences (GFZ). The data packages are documented in EnMAP Flight Campaign Technical Reports (e.g. Neumann et al., 2015b). Metadata are linked to the data packages and vice versa. EnMAP Flight Campaign Technical Reports follow a standardized template and document all available datasets in the data package including the in-situ field and lab data, additional GIS data and simulated EnMAP and Sentinel-2 data if available.

To enlarge the exchange and reusability of the campaigns, the EnMAP Campaign Portal provides:

- a graphical overview of the EnMAP campaign sites
- a set of metadata describing the campaign data packages in general
- a link to the EnMAP Flight Campaign Technical Reports that provide more detailed information about one campaign
- information about access and referencing of the campaign data packages
- field guides for standardized future data collection

The EnMAP Campaign Portal is accessible via www.enmap.org/flights. The purpose of this report is to provide an overview about the structure and content of the EnMAP Campaign Portal and to describe all technical functions and use cases.

3   Structure and content of the EnMAP Campaign Portal

The EnMAP Campaign Portal (1) provides a broad overview about all conducted campaigns within the EnMAP Data Exploitation and Application Development Program; (2) give sufficient details about each campaign, (3) informs about the data ownership and data access and (4) provides field data guidelines for a standardized data acquisition (EnMAP Field Guides Technical Reports, e.g. Danner et al., 2015).

3.1 Definition of a campaign:

Each data entry (row) in the EnMAP Campaign Portal comprises a campaign that is defined as one specific airborne hyperspectral data acquisition. This airborne data was taken during one overflight by an aircraft equipped with one or several hyperspectral sensors. This requirement is not valid for additional data from e.g. field measurements, which can differ especially in terms of sampling times and frequencies.

Table 1: Parameters providing a general overview about the campaigns collected in the EnMAP Campaign Portal

Parameter/Column	Description	Type/Format
Name	Name of the campaign that allows to assign the data entry to a specific region and country	String [≤ 24 Char]
Application	Describes the main field of application for which the campaign was primarily designed	String [≤ 24 Char]
Sensor	Name of the hyperspectral sensor system mounted on the aircraft	String [≤ 24 Char]
Product-Level	General product levels that have been produced and are available to the public; to simplify matters, only general categories are given here (L0, L1, L2*), the detailed description is given in the Data Documentation	String [≤ 24 Char]
Date	Date of hyperspectral airborne flight campaign	Date (DD.MM.YYYY)
DOI	Link to DOI landing page of the campaign data package if applicable	String [≤ 80 Char]

* Here, only rough categories of data level descriptions are given: L0=Digital Numbers, L1=Radiance, L2=Reflectance

3.2 Overview about all campaigns

The EnMAP Campaign Portal provides an overview about the location and extents of all airborne flight campaigns on a map. In addition, a set of metadata parameters are defined for each campaign (see Table 1 and Figure 1). These parameters can be used to browse for certain campaigns.

The overview information of each campaign (record/row) can be expanded to retrieve more detailed information about the campaign and related data (Figure 2, Table 2) which is provided in the campaign data packages.

Further, the EnMAP Campaign Portal provides links to a set of EnMAP Field Guides supporting the standardized acquisition of in-situ data (following international standards and recommendations in publications, e.g. Danner et al. 2015). It is recommended to use these field guides for the acquisition of field and/or laboratory data associated to airborne campaigns foreseen to be integrated into the EnMAP Campaign Portal.

Name	Application	Sensor	Product-Level	Date	DOI
search	▼	▼	▼	▼	▼
Donnersberg (DE)	Forest	HySpex VNIR-1600 HySpex SWIR320m-e	L2	Jul 3, 2014	DOI
Idarwald/Hochwald (DE)	Forest	HySpex VNIR-1600 HySpex SWIR320m-e	L1	Jun 9, 2014	-
Hunsrück-Hochwald (DE)	Forest	HySpex VNIR-1600 HySpex SWIR320m-e	L1 L2atm L2geo	May 5, 2014	DOI
Pfälzer Wald/Merzalben (DE)	Forest	HySpex VNIR-1600 HySpex SWIR320m-e	L1	Apr 16, 2014	-
Idarwald/Hochwald (DE)	Forest	HySpex VNIR-1600 HySpex SWIR320m-e	L1	Apr 10, 2014	-
Neusling (DE)	Agriculture	AVIS-3	L2geo L2	Sep 8, 2012	DOI
Neusling (DE)	Agriculture	HySpex VNIR-1600 HySpex SWIR320m-e	L2	Aug 12, 2012	DOI
Hainich (DE)	Forest	aisaHawk	L1 L2atm	Jul 24, 2012	-
Neusling (DE)	Agriculture	AVIS-3	L2geo L2	Jun 16, 2012	DOI
Neusling (DE)	Agriculture	AVIS-3	L2geo L2	May 25, 2012	DOI

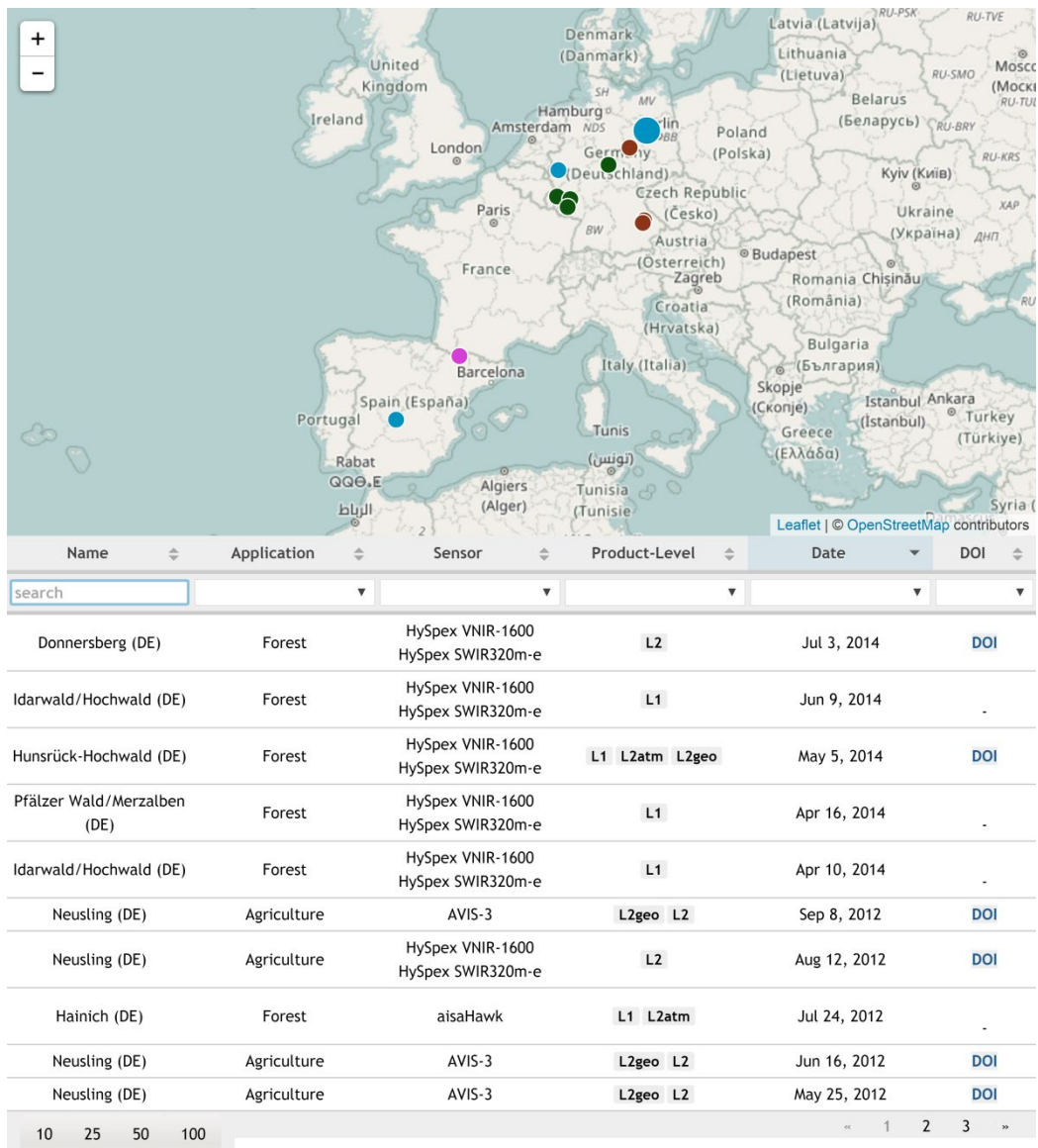10   25   50   100   «   1   2   3   »

Figure 1: Graphical User Interface of the EnMAP Campaign Portal. The map gives the location of all available flight campaigns. The table below provides a general overview on the EnMAP flight campaigns as well as search options and the possibility to change the order of flight campaigns visible for the user. More detailed information for each flight campaign can be accessed by clicking on the campaign names (Figure 2). See Table 1 for the definition of each column of the general overview.
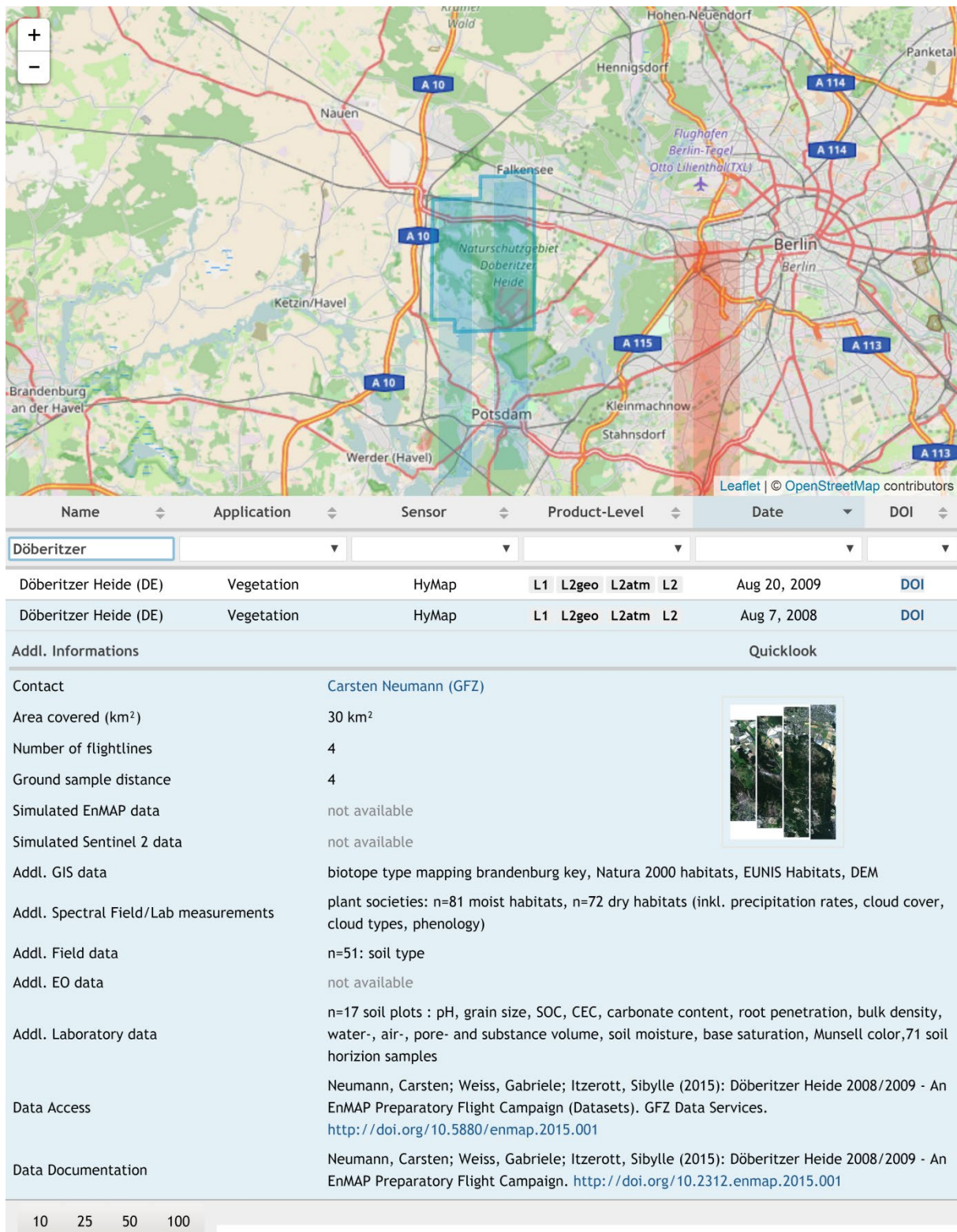
Name		Application		Sensor		Product-Level		Date		DOI	
Döberitzer		▼		▼		▼		▼		▼	
Döberitzer Heide (DE)		Vegetation		HyMap		L1 L2geo L2atm L2		Aug 20, 2009		DOI	
Döberitzer Heide (DE)		Vegetation		HyMap		L1 L2geo L2atm L2		Aug 7, 2008		DOI	

Addl. Informations		Quicklook
Contact	Carsten Neumann (GFZ)	
Area covered (km²)	30 km²	
Number of flightlines	4	
Ground sample distance	4	
Simulated EnMAP data	not available	
Simulated Sentinel 2 data	not available	
Addl. GIS data	biotope type mapping brandenburg key, Natura 2000 habitats, EUNIS Habitats, DEM	
Addl. Spectral Field/Lab measurements	plant societies: n=81 moist habitats, n=72 dry habitats (inkl. precipitation rates, cloud cover, cloud types, phenology)	
Addl. Field data	n=51: soil type	
Addl. EO data	not available	
Addl. Laboratory data	n=17 soil plots : pH, grain size, SOC, CEC, carbonate content, root penetration, bulk density, water-, air-, pore- and substance volume, soil moisture, base saturation, Munsell color,71 soil horizion samples	
Data Access	Neumann, Carsten; Weiss, Gabriele; Itzerott, Sibylle (2015): Döberitzer Heide 2008/2009 - An EnMAP Preparatory Flight Campaign (Datasets). GFZ Data Services. http://doi.org/10.5880/enmap.2015.001	
Data Documentation	Neumann, Carsten; Weiss, Gabriele; Itzerott, Sibylle (2015): Döberitzer Heide 2008/2009 - An EnMAP Preparatory Flight Campaign. http://doi.org/10.2312.enmap.2015.001	

10   25   50   100

Figure 2: Detailed information of an EnMAP Flight campaign (example Döberitzer Heide 2008). See Table 2 for the explanation of each metadata field.

Table 2: Detailed parameters of the campaign data packages

Parameter	Description	Type/Format
Contact	It directs to the person (and institution) in charge for designing and managing the campaign. Please note that the data set contact is defined in the data set publication (DOI link). If there is no DOI link yet, the person named here is the responsible contact person.	String [≤ 24 Char]
Area covered (km²)	Approximates the area in km² covered by hyperspectral airborne data.	Number
Number of flight lines	Number of flight lines	Number
Ground sample distance	The Ground Sampling Distance (GSD) is the distance between two consecutive pixel centers measured on the ground	Number
Simulated EnMAP data	Indicates, if EnMAP data have been simulated (available) or not (not available)	Boolean
Simulated Sentinel 2 data	Indicates, if Sentinel-2 data have been simulated (available) or not (not available)	Boolean
Add. GIS data	Specifies the available further (spatial) GIS information related to the respective airborne flight campaign (keywords)	String [≤ 80 Char]
Add. Spectral Field/Lab measurements	Specifies information about additional spectral lab and/or field measurements that have been collected associated to the respective airborne flight campaign	String [≤ 80 Char]
Add. Field data	Specifies additional field data that have been collected during the respective airborne flight campaign	String [≤ 80 Char]
Add. Earth Observation (EO) data	Specifies additional EO data associated to the respective airborne flight campaign	String [≤ 80 Char]
Add. Laboratory data	Specifies additional laboratory data associated to the respective airborne flight campaign	Date
Data Access	Citation of the campaign and link to the campaign data package	Text [≤ 300 Char] String [≤ 80 Char]
Data Documentation	Citation of the campaign and link to the campaign data description	Text [≤ 300 Char] String [≤ 80 Char]
Quicklook	Down-sampled image of the airborne hyperspectral data	Image [≥ 110px on shorter side]

4   Functionality of the EnMAP Campaign Portal

The graphical user interface (GUI) of the EnMAP Campaign Portal is divided into two parts: the "Mapview" and a "Tableview" below (see Figure 1 and 2).

The **Mapview** at the top is based on a cross-browser and touch-optimized web-mapping library named "Leaflet" (http://leafletjs.com/). It provides all of the functionality a user would expect from a so called "slippy map", namely to zoom and pan around the viewport of the map. The main purpose of the Mapview is the presentation of the test sites to show their localization and extend. Color classified semitransparent polygons get drawn on a base layer of Open Street Map data. To keep the test sites visible and selectable when zoomed out to a national or global scale the polygons collapse to circle markers with a fixed size at the breakpoint of zoom level 7 and below. A click on either a polygon or a marker results in an animated repositioning of the viewport to give the selected site focus.

This focusing gets also applied to the corresponding row in the **Tableview**, resulting in a highlighted state (see Figure 2). To ensure the coherence between both views a two-way binding with a shared

model was implemented. Therefore, the EnMAP Campaign Portal uses the library "AngularJS" (https://angularjs.org/) and its MVC-pattern (Model-View-Controller) as a framework to structure functionality and visualizations into separate but interconnected components. The Tableview itself is using an AngularJS extension called "ng-table" that simplifies very common table operations like sorting, filtering and pagination. While the latter is placed as usual at the very bottom of the EnMAP Campaign Portal in the table footer, sorting and filtering is accessible to the user through the two rows in the table header. The first row shows the names of the 6 corresponding columns beneath together with little up- and down-facing arrows to indicate the possibility to change the sorting as well as its current state (see also Table 1 for further description). The second header-row gives the user the ability to filter the records shown in the table (Figure 2). With exception of the first column "Name" a so called "select-input" with a set of reasonable predefined options is placed on top of every column (e.g. a click on the header of the "Date" column allows to filter on the year when a flight campaign was taking place, see Figure 3). Because of the lack of meaningful options the "Name" column is an exception and has a "text-input" instead. It allows a user to search for a string in the name property of the records, and furthermore in all the other textual properties of a record. In line with all the other filters a successful search results in a reduced number of records in the table, showing only the matches of the applied filter.
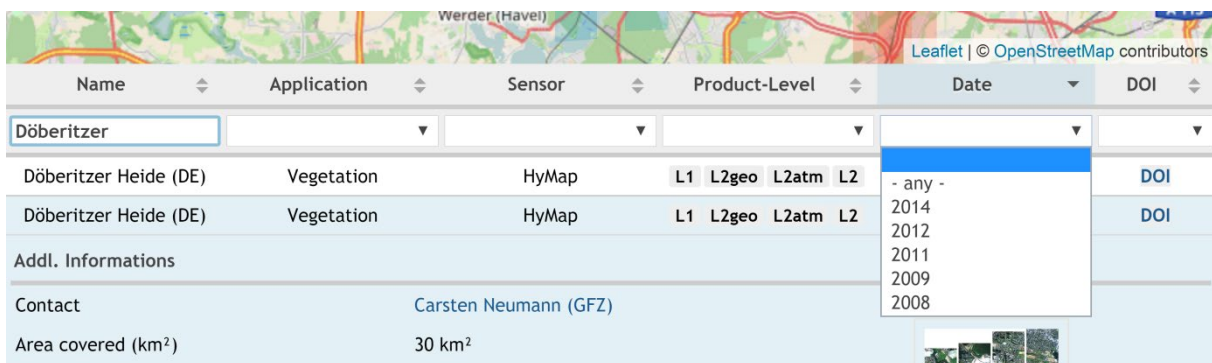

Figure 3: Example of filter options of the EnMAP Campaign Portal (here to filter the campaigns using the year during which a flight campaign was conducted).

The records (flight campaigns) themselves are displayed in the table as one row each. At first they consist of the values for the 6 main properties as defined by the column names: Name, Application, Sensor, Product-Level, Date and DOI (see Table 1 and Figure 1). As already mentioned, every record can be focused by clicking on it. In the selected state the table row of a record is expanded to unveil some additional information. Besides a quicklook image and a contact link some statistical values and the availability of additional related datasets is shown to the user (see Table 2 and Figure 2). This section gets collapsed when another record gets focused or the user clicks on a row a second time.

The metadata base of the EnMAP Campaign Portal was designed as an independent, standalone module to ease the integration in any existing webpage. It comes with its own CSS (Cascading Style Sheet), JS (JavaScript) and HTML (Hypertext Markup Language) and is bundled to only three files of code. For the data shown in the EnMAP Campaign Portal a static JSON file (JavaScript Object Notation) acts as the table of contents (TOC). Together with a folder of quicklook images it is a portable and adaptive, simple but effective solution that can be extended easily whenever new campaigns have taken place.

5   Integrating new campaigns

The EnMAP Campaign Portal will be extended when new campaign data become available. Adding a new campaign to the portal requires information about its properties, geographic information as well as the quicklook image that needs to be provided by the person/institute responsible for the campaign (researcher). The final record that is put in the TOC must follow a strict computer-optimized scheme and is created in a semi-automated way from the available data provided by the researcher. A simple excel-sheet has been created that request the information in a standardized way (see Figure 4).

name	description	type/format	required/count
name	Name of the area (country code)	String [≤ 24 Char]	1
date	Date of the flight	Date (DD.MM.YYYY)	1
application	"Forest", "Agriculture", "Vegetation", etc.	String [≤ 24 Char]	1
sensor	"HyMap", "aisaDual", etc.	String [≤ 24 Char]	1-2
productlevel	"L1", "L2geo", etc.	String [≤ 24 Char]	1-5
area	Area covered (km²)	Number	0-1
gsd	Ground sample distance	Number	0-1
flightlines	Number of flightlines	Number	0-1
simEnmap	Simulated EnMAP data	Boolean	1
simSentinel2	Simulated Sentinel 2 data	Boolean	1
addGis	Addl. GIS data	String [≤ 80 Char]	0-1
addSpec	Addl. Spectral Field/Lab measurements	String [≤ 80 Char]	0-1
addField	Addl. Field data	String [≤ 80 Char]	0-1
addEO	Addl. earth observation data	String [≤ 80 Char]	0-1
addLab	Addl. Laboratory data	String [≤ 80 Char]	0-1
comments	Further comments	Text [≤ 300 Char]	0-1
contactName	Person in charge (organisation)	String [≤ 80 Char]	1
contactMail	Email adress	String [≤ 80 Char]	1
doiAccess	citation	Text [≤ 300 Char]	1
doiAccessURL	DOI URL	String [≤ 80 Char]	1
doiDoc	citation	Text [≤ 300 Char]	1
doiDocURL	DOI URL	String [≤ 80 Char]	1
quicklook	Downsampled image of the data	Image [≥ 110px on shorter side]	1
geometry	Georeferenced polygon of the coverd area	KML, SHP, GeoJSON, WKT, etc.	1

Figure 4: Request form to integrate new campaigns into the EnMAP Campaign Portal

6   Data availability and access

All data on this website are provided free of charge under a Creative Commons Attribution-ShareAlike 4.0 International License (CC-BY-SA) and is subject to the following terms and license conditions:

For data access, the interested user shall fill in the contact form at the DOI Landing Page of the respective flight campaign and will then be provided with an FTP link for download. If there is no DOI available yet, the user may contact the responsible person listed in the Tableview (Contact).

7   Summary / Conclusions

The primary goal of the EnMAP Campaign Portal is to enable the discovery, sharing and re-use of hyperspectral airborne and (simulated) spaceborne data to stimulate algorithm and application development for the future availability of EnMAP data and for any EO based research. The publication

and detailed description of the airborne data together with further campaign data such as laboratory and field surveys or EnMAP data simulations is unique for this Portal and yield the potential for other researchers to explore the data packages. Thus, the research network and community will be increased/enlarged to widen the scope of using EnMAP data for a wide range of research and applications, to foster the integrated use of spaceborne hyperspectral and multispectral data and thus, to stimulate spectroscopic techniques at the EO market. The EnMAP Campaign Portal will be constantly extended with new data packages during the mission lifetime.

8   Acknowledgements

9   References

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