EnMAP Flight Campaigns
Technical Report

Demmin, Germany (October 2015) - an EnMAP Preparatory Flight Campaign

Maximilian Brell, Daniel Spengler, Thomas Ruhtz, Kathrin Ward, Sabine Chabrillat, Karl Segl, Saskia Foerster, Sibylle Itzerott

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Demmin, Germany (October 2015) - an EnMAP Preparatory Flight

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GFZ German Research Centre for Geosciences

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Abstract

The dataset is composed of Hyspex (VNIR/SWIR) hyperspectral imagery acquired during airplane overflights on October 1, 2015 within the Demmin Research Area. The acquisition conditions were cloud free. The dataset includes two mosaics generated based on 9 HySpex flight lines. The dataset also includes Level 2A EnMAP-like imagery simulated using the end-to-end Simulation tool (EeteS). Additionally, a soil database focusing on the soil organic carbon content (SOC) with geographic coordinates, SOC content, texture and spectral information is included.

Coordinates: **center:** 53.92N / 13.10 E

Keywords: Hyperspectral Imagery, Soils, Landuse, Agriculture

Related sources:

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., …, and Sang, B. (2015). The EnMAP spaceborne imaging spectroscopy mission for earth observation. *Remote Sensing*, 7(7), 8830-8857. https://doi.org/10.3390/rs70708830

A full description of the EnMAP end-to-end simulation tool is provided in Segl et al. (2012):

Segl, K., Guanter, L., Rogass, C., Kuester, T., Roessner, S., Kaufmann, H., Sang, B., Mogulsky, V., & Hofer, S. (2012). EeteS—The EnMAP end-to-end simulation tool. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 5, 522-530. https://doi.org/10.1109/JSTARS.2012.2188994

A general description of the airborne preprocessing principles is provided in Brell et al. (2016):

Brell, M., Rogass, C., Segl, K., Bookhagen, B., Guanter, L., 2016. Improving Sensor Fusion: A Parametric Method for the Geometric Coalignment of Airborne Hyperspectral and Lidar Data. IEEE Transactions on Geoscience and Remote Sensing 54, 3460–3474. https://doi.org/10.1109/TGRS.2016.2518930

This dataset has been used in several studies:

Castaldi, F., Hueni, A., Chabrillat, S., Ward, K., Buttafuoco, G., Bomans, B., Vreys, K., Brell, M., van Wesemael, B. (2019): Evaluating the capability of the Sentinel 2 data for soil organic carbon prediction in croplands. ISPRS Journal of Photogrammetry and Remote Sensing, 147, 267-282. https://doi.org/10.1016/j.isprsjprs.2018.11.026

Castaldi, F., Chabrillat S., and van Wesemael, B. (2019): Sampling strategies for soil property mapping using multispectral Sentinel-2 and hyperspectral EnMAP satellite data. Remote Sensing, 11(3), 309. https://doi.org/10.3390/rs11030309

Ward, K.J., Chabrillat, S., Brell, M., Castaldi, F., Spengler, D., Foerster, S., 2020. Mapping Soil Organic Carbon for Airborne and Simulated EnMAP Imagery Using the LUCAS Soil Database and a Local PLSR. Remote Sensing 12, 3451. https://doi.org/10.3390/rs12203451

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 Licence CC BY 4.0 Licence. An overview of all available data is provided in a specifically developed metadata portal on the project website (https://www.enmap.org/data_tools/flights/).

Flight Campaign "Demmin October 2015"

The study site is located in North-East Germany. The covered area is characterized by intensive agricultural land use. DEMMIN (***D****urable* ***E****nvironmental* ***M****ultidisciplinary* ***M****onitoring* ***I****nformation* ***N****etwork*) is a permanent Calibration/Validation (Cal/Val) test area which was designed specifically for remote sensing applications, focusing on agriculture. The data acquired in DEMMIN contribute specifically to strengthen the Copernicus in situ component in terms of quality assurance of the information products derived by remote sensing data. The study site is located in Northeastern Germany and covers an area of about 900 km^2 dominated by agricultural use, but with smaller areas of forest, rivers and lakes, centered by the city of Demmin (which intentionally coincides with the abbreviation of the study site). The site has been established in 2000, based on a partnership of the German Aerospace Center (DLR) and local farmers. Since 2011, DEMMIN is part of the TERENO North Eastern Lowlands Observatory (TERENO-NE) and is under the responsibility of the Helmholtz Centre Potsdam GFZ, the German Research Centre for Geosciences. In cooperation with the DLR, and the Research Center Jülich (FZJ) the existing environmental measurement network for the acquisition of environmental parameters was extended by further measurement stations, a Lysimeter hexagon, a soil moisture network under agricultural fields, and a research crane platform in the forest. The permanent measurements are supplemented by regular airborne and in situ field campaigns for specific research objectives for, e.g., vegetation, soil or water parameter estimation and management information from local farmers. This large data base allows developing and validating remote sensing-based products. The morphology of this area was formed by periodic glacial processes during the Pleistocene (Weichselian Glaciation) and thus it is part of the young morainic soil landscape of Northern Germany. Haplic Luvisols, Eutric Podzoluvisols and Stagnic Luvisols from boulder clay are dominant soils in this area.

2 Data Acquisition

Nine flight stripes were acquired during an EnMAP GFZ/ FUB flight campaign operated by the GFZ using the HySpex VNIR-1600 and HySpex SWIR 320m-e ("HySpex, Norsk Elektro Optikk," 2015) imaging spectrometers over the DEMMIN test field on October 01, 2015 (10:07-11:01 local time). Over the nine flight stripes, three are located in the Western part of the area over the village of Borrentin and Nossendorf, and six in the Eastern part of the area over the villages of Alt-Tellin, Jarmen and Sassen covering mainly agricultural fields (Figure 1). For this campaign the HySpex imaging system was mounted on the Cessna 207T aircraft of the "Freie Universität Berlin" (FUB). The HySpex hyperspectral imaging system is based on two separated push-broom hyperspectral cameras HySpex VNIR-1600 and HySpex SWIR 320m-e which cover the wavelength domain from 0.4-1.0 µm and 1.0-2.5 µm respectively, with a spectral resolution of 3.7 nm (VNIR-1600) and 6.0 nm (SWIR-320m-e). Both sensors were flown with a field of view expander which results in field of view of 33.2° for the VNIR and 26.4° for the SWIR. The position and attitude of the airplane were measured with an AEROcontrol-IId inertial measurement unit (IMU) with available data rates of 256 Hz in combination with a Novatel OEM4 - g2 GPS receiver. The HySpex sensors (VNIR, SWIR) and DGPS/IMU sensors were arranged on an active stabilization platform (SM2000).

The entire airborne campaign was conducted at a mean altitude of 2500 m which results in a mean ground sampling distance (GSD) of 1.9 m for the VNIR and 3.8 m for the SWIR. The overflight encompassed an area of approximately 23000 ha.

Time: October 01, 2015 start: 10:07-11:01 (local time)
Bands: 390/408
Wavelengths: 414.8– 2500 nm

Table 1: Overview of the two hyperspectral imaging airborne mosaics

	Flight Altitude	**Flight Heading**	**Solar Azimuth**	**Solar Zenith**	**Pixel Size**	**Lines**	**Bands**	**Wave lengths**
Demmin_mosaic_west	2500 m	N-S and S-N direction	144.1°	62.8	4.0 m	3	408	414.8-2500 nm
Demmin_mosaic_ost	2500 m	N-S and S-N direction	143.9°	62.8	4.0 m	6	390	414.8-2396 nm

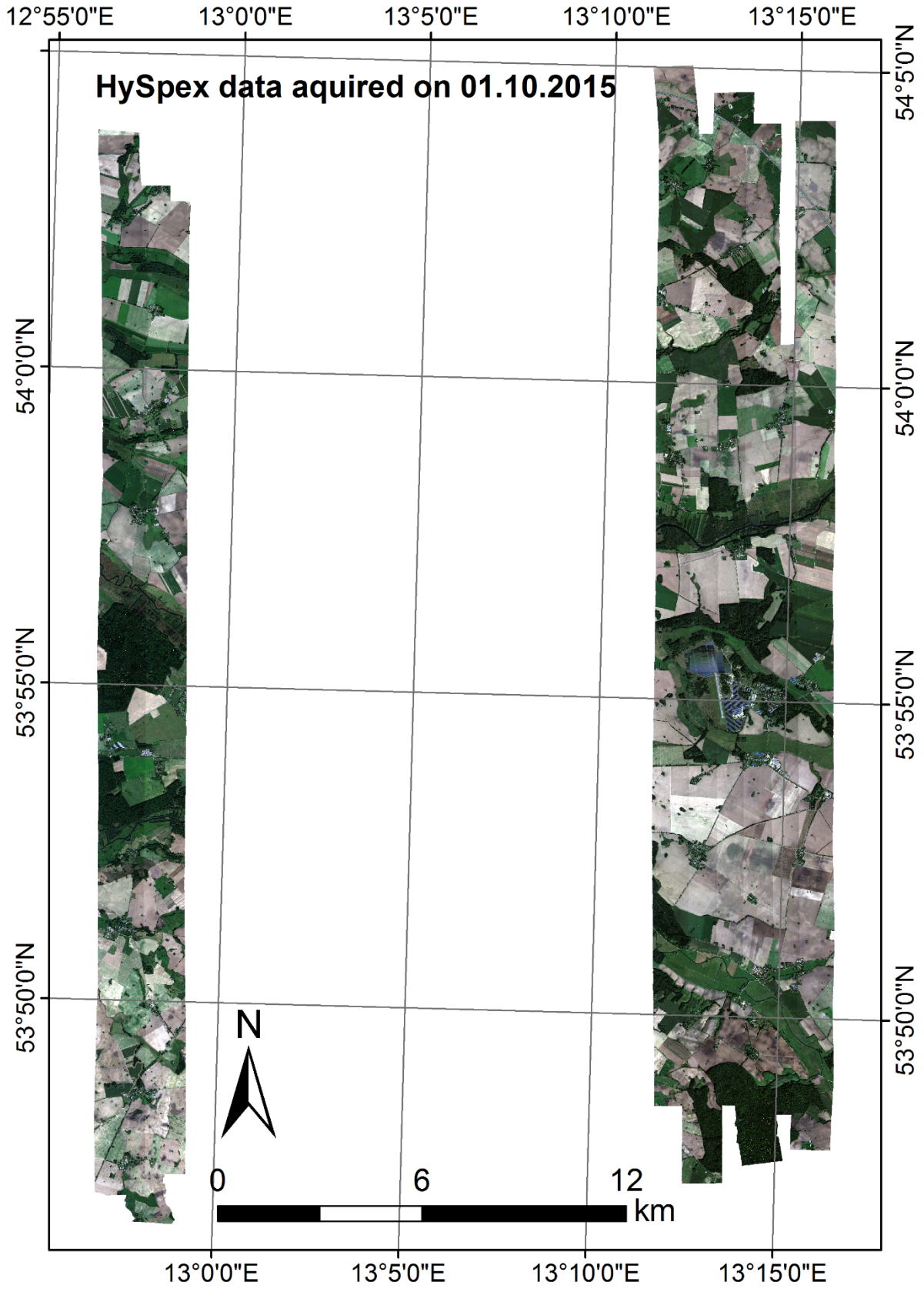

Figure 1: Overview of the HySpex data visualized as RGB composite.

3 Data Processing and Products

The acquisition data was radiometrically corrected using sensor specific software of the instrument manufacturer. The direct geometric correction, co-alignment and adaptation of the SWIR sensor to the VNIR was performed with the in-house processing chain HyPrePair based on the sensor models and the simultaneously measured IMU/GPS data stream (Brell et al., 2016). Subsequently, the stacked VNIR/SWIR data cube was atmospherically corrected with the ATCOR-4 software (Richter and Schläpfer, 2002). And finally, an ENVI seamless mosaicking of the single flight lines was realized. After the preprocessing of the HySpex data (georectification, sensor co-registration, atmospheric correction, mosaicking) the hyperspectral data cube consists of a total of 408 bands (Western part) and 390 bands (Eastern area) resampled to 4 m pixel resolution (Table 1).

Simulated EnMAP data were generated using the EnMAP end-to-end simulation software (Segl et al., 2012), resulting in two simulated hyperspectral data cubes of 242 bands.

4 File Description

4.1 File Format

Envi Image File [*.bsq] and file header [*.hdr]. Excel file [*.xlsx] for the additional soil database.

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 (full width half maxima)

The Excel table containing the soil database includes the following attributes:
Sample ID, geographic coordinates, organic carbon content of the topsoil samples, texture and ASD FieldSpec 3 laboratory spectra.

5 Data Quality

5.1 Hyperspectral data

Due to the campaign date in October, the illumination conditions were non-optimal which results in a relatively low signal-to-noise ratio (SNR). Additionally, dark soil surfaces with less reflectivity made the acquisition conditions challenging.

5.2 EnMAP simulation

The quality of simulated EnMAP data is related to the quality of the HySpex data that the simulation was based on. The illumination changes affect the EnMAP data as well.

6 Additional Data

The associated soil database focusses on the soil organic carbon content (SOC) and additionally includes geographic coordinates, texture and spectral information. It consists of 62 top soil samples (0-10 cm depth) which were collected in the test site area on October 6 and 16, 2016. Each sample consists of a mixture of five sub-samples taken within a radius of 5 m around the given coordinate. These samples were dried at 40°C, crushed and sieved (<2 mm). The SOC content was extracted by dry combustion using a VarioMax CN Analyzer (Elementar Analysensysteme GmbH, Germany). It ranges between 6.4-169 g kg^{-1} with a median of 10.3 g kg^{-1} and a mean of 16.0 g kg^{-1}. Texture was measured in the laboratory according to DIN / ISO 11277. Laboratory spectra were acquired using an ASD FieldSpec which provides reflectance data at 1 nm interval and a range of 350 – 2500 nm.

7 Dataset Contact

If you need additional information, byproducts, single flight stripes or a specialized preprocessing please contact:

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