EnMAP Flight Campaigns

Technical Report

Neusling (Landau a.d. Isar) 2009
An Agricultural EnMAP Preparatory Flight Campaign using the HyMap Instrument

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Neusling (Landau a.d. Isar) 2009 - An Agricultural EnMAP Preparatory Flight Campaign using the HyMap Instrument

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Abstract

This data collection contains airborne hyperspectral data as well as accompanying in-situ data acquired in autumn 2009 in the Neusling test area near Landau a.d. Isar in Southern Germany. The dataset is composed of a) two airborne hyperspectral image strips acquired during an overflight on July 27th, 2009 with the HyMap instrument over two areas; "Neusling" and "Steinbeissen". The airborne data consists of 125 spectral bands, ranging from VIS to SWIR (455 - 2478 nm); b) spectral reference measurements acquired with a portable ASD FieldSpec 3 JR spectroradiometer in 2150 spectral bands (350 - 2500nm) taken parallel to the overflight; c) spatially comprehensive land use/land cover maps for both flight strips generated from in-situ observations during the days next to the overflight; d) Flight-parallel in-situ point-measurements consisting of: i) destructively measured aboveground dry biomass and canopy water content of maize, sugar beet and winter wheat (58 measurements), ii) non-destructive measurements of LAI of sugar beet and maize (52 measurements), iii) TDR soil moisture measurements covering the main land cover types in the area (250 measurements), iv) 249 measurements of canopy height, v) 199 observations of plant phenology. The dataset was intended to be used in an educational context and was collected with an agricultural focus.

Coordinates		
Area:	**Neusling**	**Steinbeißen**
Center:	48,68° N / 12,87° E	48,57° N / 12,74° E
Upper Left:	48,74° N / 12,87° E	48,63° N / 12,70° E
Upper Right:	48,74° N / 12,90° E	48,63° N / 12,73° E
Lower Left:	48,62° N / 12,83° E	48,50° N / 12,75° E
Lower Right:	48,61° N / 12,87° E	48,50° N / 12,78° E

Keywords: Hyperspectral Imagery, Field Spectroscopy, Agriculture, Biomass, Canopy Water Content, LAI

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 dataset has been achieved in the frame of the cooperative project described in

Bachmann & Weide (2010): *Bachmann, M. & Weide, S. (2010): EnMAP-Nutzungsvorbereitung – Unterstützung der Hochschulforschung mit HyMap-Hyperspektraldaten: Abschlussbericht; Berichtszeitraum: 2009-2010, Deutsches Zentrum für Luft- und Raumfahrt.*

The data set has also been described and scientifically applied in Hank et al. (2010):

Hank, T., Marzahn, P., Schlenz, F. & Mauser, W. (2010): Assessing Moisture Conditions of Heterogeneous Landsurfaces through Hyperspectral Analysis of Water Absorption Features, Proceedings of the 'Hyperspectral Workshop 2010,' ESRIN (ESA SP-683, May 2010), ISBN 978-92-9221-247-6, ISSN 1609-042X, Frascati (Italy)

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 extract-ing 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 preparato-ry phase, pre-flight campaigns including airborne and in-situ measurements in different environ-ments and for several application fields are being conducted. The main purpose of these cam-paigns 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 "Neusling" and "Steinbeißen" 2009

The scientific work summarized in this data report was accomplished from July 2009 to February 2010 through a scientific collaboration of the Ludwig-Maximilian-University Munich (LMU) with the German Remote Sensing Data Center (DFD) as part of the German Aerospace Center (DLR) in the frame of a BMBF funded cooperative project titled "EnMAP-Nutzungsvorbereitung Unterstützung der Hochschulforschung mit HyMap-Hyperspektraldaten [EnMAP mission preparation – Support college research through provision of hyperspectral HyMap data]". The cooperative proposal was designed to initiate a collaboration of 13 German Universities in the field of hyperspectral remote sensing. The basic idea of the project was the provision of reliable hyperspectral data sets for educational purposes, contributing to the building of knowledge in hyperspectral issues in the context of the expected launch of the hyperspectral pioneer research satellite system "Environmental Mapping and Analysis Program" (EnMAP).

Moreover, the data set was intended to provide the opportunity to exploit, develop and validate algorithms for the retrieval of land surface variables from the simulated EnMAP configuration.

The LMU contribution focused on the generation of a data base containing agriculturally relevant land surface characteristics, which are observed parallel to hyperspectral remote sensing data acquisitions of the HyMap airborne imaging system.

In total, seven different biophysical variables and land surface characteristics were measured or observed in the field, including 'aboveground biomass', 'leaf area index' (LAI), 'canopy water content', 'soil moisture', 'canopy height', 'phenological stage' and 'field spectral reflectance'. Moreover, a land cover map was generated, covering the whole extent of the scheduled HyMap acquisitions.

Consequently, the major workload was associated with the ground measurement campaigns, which took place from July 26th to 28th and from August 3rd to 5th 2009, temporally enclosing the HyMap acquisition. The hyperspectral images could be successfully recorded on July 27th in the selected test area. Whereas the preprocessing of the hyperspectral data including geometric and radiometric corrections was provided by DLR/DFD, processing of the collected ground measurement samples was conducted in the laboratories of the LMU. The measured ground biophysical data set was summarized

in tabular form and georeferenced integrating the GPS defined sample points into a geographic information system (GIS).

The consistent data set can on one hand be applied to the further development of retrieval strategies for agricultural variables, and on the other hand provides a detailed and promising data base for hyperspectral educational programs with agricultural focus.

The activities of this study concentrated on an area in the eastern part of southern Germany (Fig. 1.01, left). The study area is situated in eastern Bavaria approximately 100 km northeast of the capitol city of Munich, embedded between the cities of Dingolfing, Plattling and Eggenfelden (Fig. 1.01, right). This part of southern Germany can best be described as a temperate area intensively used for agricultural purposes. The outlet of the river Isar into the Danube is located about 10 km northeast of the study area, where the low mountain range of the 'Bavarian Forest' begins to rise just behind the valley of the river Danube.

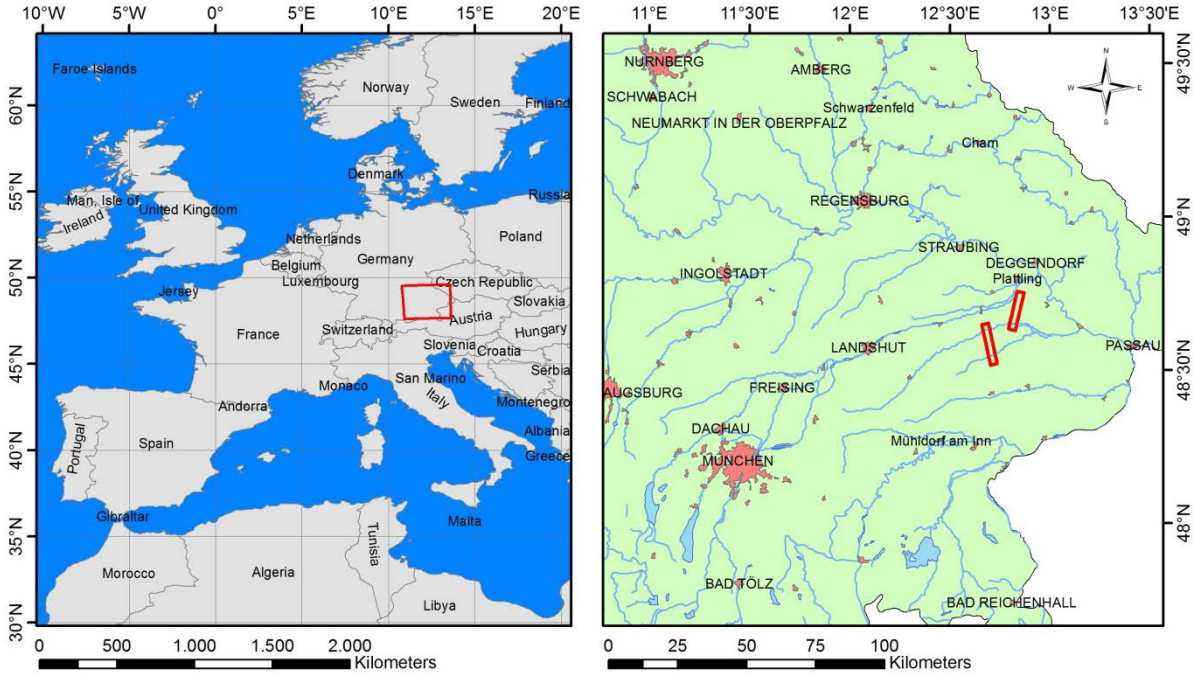

Figure 1.01: Location of the study area 'Landau an der Isar' as part of Central Europe (left = overview) and location of the two separate flight strips relative to Bavarian cities and rivers (right = detail). The extent of the detail map is indicated in the overview map (left) through a red rectangle, while the actual extent of the two separate flight strips is traced by equally red rectangles in the detail map (right).

The study area can be divided into two parts with different natural characteristics. The north-eastern part of the test area is defined through the village of Neusling (342 m above sea level = asl), while the south-western test site encircles the village of Steinbeißen/Haunersdorf (384 m asl). Both test sites are located about 10 km apart from each other.

Several reasons contributed to the selection of this test area for the campaigns. First of all, the region is part of a test site that was targeted in the DLR-funded project SMOSHYD, which aimed at supporting ESA in the cal/val phase of the SMOS satellite mission. This can be considered as advantage, since contacts to farmers who were willing to cooperate were already established in the Landau area, guaranteeing access to agricultural farms covered with the crops of interest. Several measurement

stations, continuously recording soil moisture, are also installed in the area. Two of them are situated next to the villages of Neusling and Steinbeißen. The operational soil moisture measurements are accompanied by meteorological stations from the agrometeorological measuring network operated by the Bavarian State Research Center for Agriculture (LFL).

The ground sampling was mainly performed in the area next to the meteorological and soil moisture measurement stations. Thus, characteristics of the landscape surrounding these stations are described in more detail in the appendix (10.1).

2 Data Acquisition

In this section, airborne and ground radiometric measurements collected in the frame of the project are described.

The actual flight campaign was designed and carried out by the Optical Airborne Remote Sensing and Calibration Facility (OpAirs) of the German Aerospace Center (DLR) in Oberpfaffenhofen (Germany).

During the planning process of the flight campaign, the LMU proposed two flight lines following the measuring transects that cross the test area Landau a.d. Isar in a more or less North to South orientation. One flight line was positioned above the village of 'Neusling', approximately 15 km east of the city of Landau, while the other was located about 7 km south of Landau above the village of 'Steinbeißen'. Both flight lines were designed to be 10 km long, while covering an across track swath of approximately 2 km. The average terrain elevation of 350 m asl required a minimum flight level of 2150 m asl in order to obtain a ground resolution of approximately 4 x 4 m taking into account the system characteristics of the HyMap sensor with a field of view (FOV) of 60° and 512 pixels per line. Table 2.01 summarizes the proposed flight lines for the test area Landau.

Table 2.01.: Proposed HyMAP-Flight lines for the test area ‚Landau an der Isar'.

Flight line	1 ‚Neusling'		2 ‚Steinbeißen'	
Start coordinate (N/E)	48°43'58.82"	12°53'11.77"	48°37'24.80"	12°43'28.77"
Target coordinate (N/E)	48°38'30.62"	12°51'31.26"	48°32'10.67"	12°45'24.96"
Heading	approx. 193° SSW		approx. 166° SSE	
Elevation	approx. 350 m asl		approx. 430 m asl	
Flight level	7000 feet asl		7400 feet asl	
Geom. resolution	4 m		4 m	
Swath (across/along)	2 km	10 km	2 km	10 km

Two flight lines of HyMap data could be successfully acquired on the 27th of July 2009 around noon (10:00 UTC). Cloud fraction of less than 1/8 contributed to perfect measurement conditions (see Fig. 2.01).

First quicklooks of the recorded data in *.jpg format were already available on the 28th of July 2009. Even though the geometry of the true colour quicklooks was still uncorrected it could be verified that the spatial extension of the HyMap acquisitions matched almost perfectly the desired boundaries and even exceeded the designated target areas in length (see Fig. 2.02). Therefore, the ongoing mapping activities in the field were extended to meet the actual dimension of the dataset.

Figure 2.01: Clear sky conditions during the HyMap flight at 10:00 UTC on July 27th 2009.

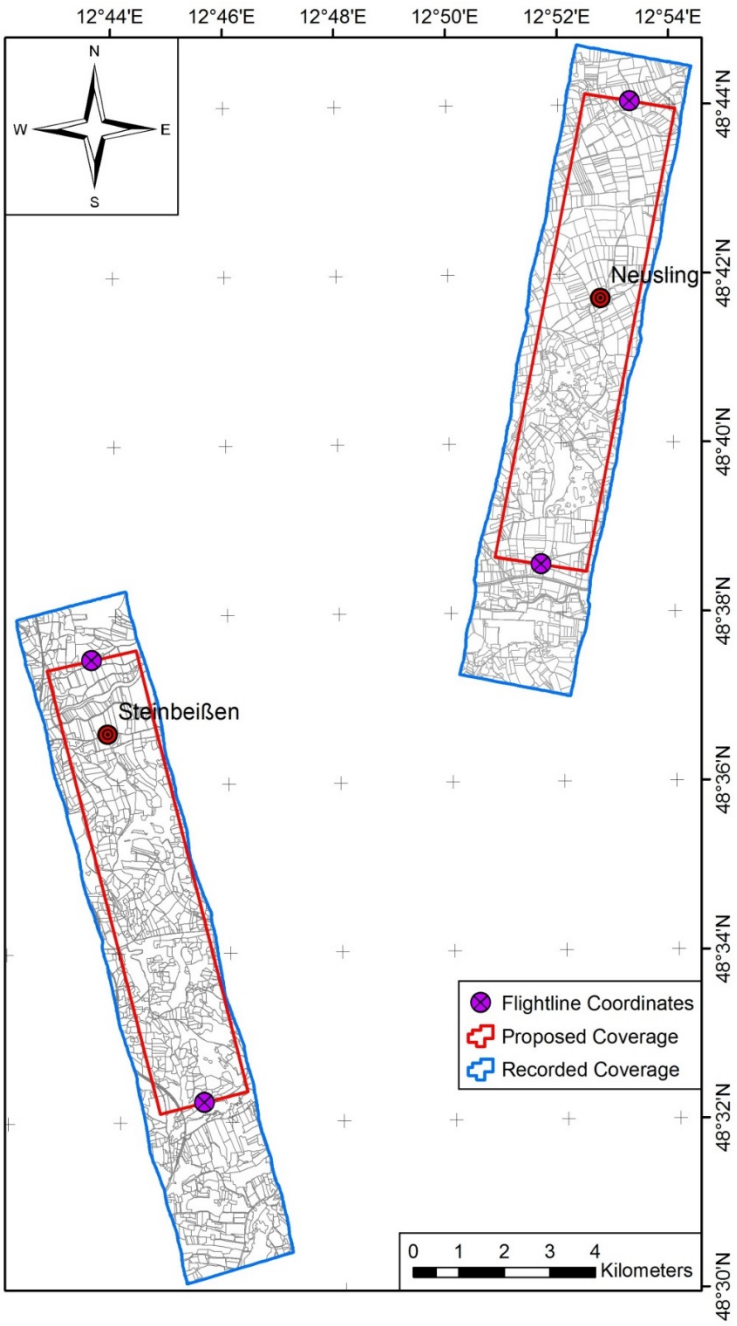

Figure 2.02: Proposed and actually recorded spatial coverage of the two HyMap acquisitions from July 27th 2009.

3 Data Processing and Products

3.1 Airborne Data

Level 2: The HyMap data were delivered by the DLR-DFD through OpAirs on the 19th of February 2010 in ENVI-format (*.hdr, band sequential) at processing level 2. Due to the sound GPS signal during the stable weather conditions that accompanied the recording flight, geometric correction procedures performed very well. The atmospheric correction of the imagery was conducted by DLR using the well-established ATCOR-4 software environment (Richter, 2008). Only minor deviations had to be rectified in the resulting level 2 data using ground control points (GCP) with the help of ERDAS 9.3 (Fig. 3.03). The GCPs were derived from a digital orthophoto product, which was kindly provided free of charge by the Bavarian land survey office. The geometric distortions were small enough to allow for the application of a first order polynomial transformation using a nearest neighbour resample method. A relatively small number of GCPs was therefore sufficient for the geometric co-registration of the hyperspectral data with the GIS database (see appendix 10.2).

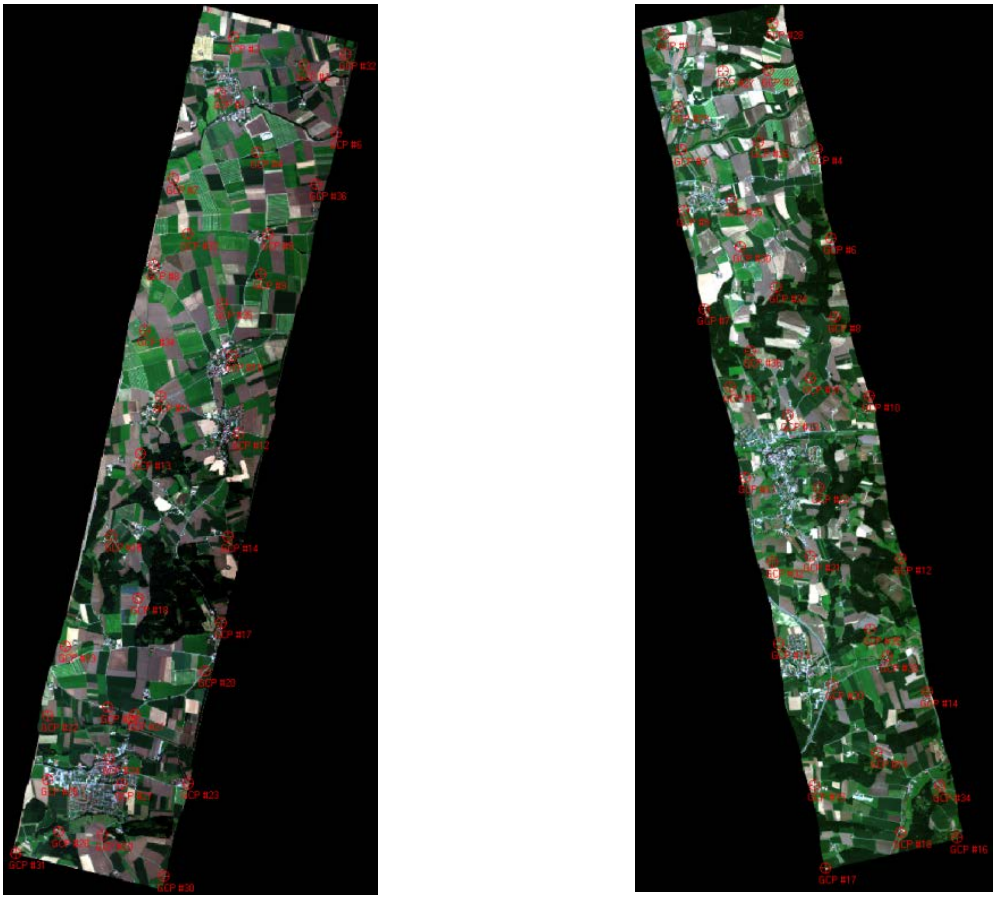

Figure 3.03: Geometric processing of both HyMap acquisitions using GCPs and a 1st order polynomial nearest neighbour transformation in ERDAS 9.3 (Neusling: left, Steinbeißen: right).

The geometric transformation resulted in two independent data sets with characteristics as summarized in Table 3.02. The original 128 spectral bands were reduced to a number of 125 during the radiometric preprocessing.

Table 3.02: File characteristics of the two HyMap scenes (Neusling and Steinbeißen) after the geometric preprocessing.

Data set:	1 ‚Neusling'	2 ‚Steinbeißen'
Geometric resolution:	4 x 4 m	4 x 4 m
Number of rows:	3610	3840
Number of columns:	1408	1384
UTM easting, lower left corner:	340496	330825
UTM northing, lower left corner:	5387014	5374422
Number of spectral bands:	125	125

The spectral wavelengths corresponding to the bands of the HyMap sensor are available in the appendix (10.3).

3.2 Simulated EnMAP Data

In June 2015, a selected section of the Neusling image strip was used to simulate an EnMAP satellite image using the EnMAP-End-to-End-Simulation tool (EeteS; Segl et al. 2012). The simulation was kindly performed by Karl Segl from the Helmholtz-Center Potsdam.

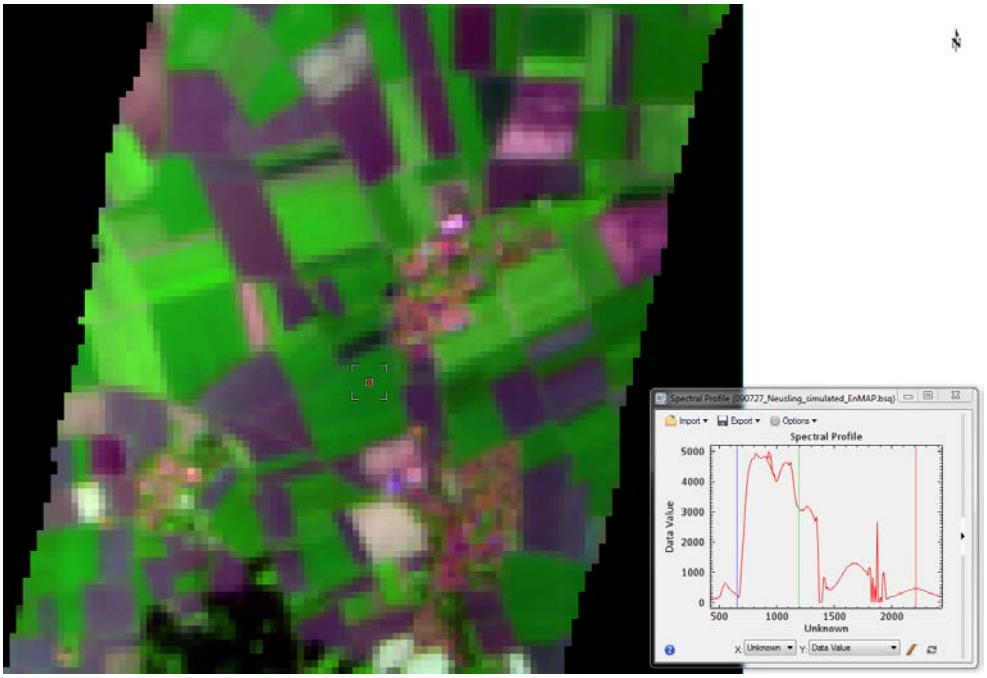

Figure 3.04: Artificial EnMAP image derived from the HyMap image of the Neusling test site from June 27th 2009.

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, data type, byte order, interleave, file type, description, map info, wavelength units, band names, wavelength, fwhm

5 Data Quality

Results of the conversion from spectral radiance into reflectance signatures were evaluated with the field spectrometer data. Comparison of ground-based and obtained HyMap reflectance confirmed a sound performance of the atmospheric correction with high correlations for all investigated land cover categories. Root mean square errors (RMSE) between ASD and HyMap spectra were calculated, resulting in minimum RMSE of 0.007 (visible wavelength region) to a maximum RMSE of 0.068 (in the red edge).

In figure 5.01, some results of the comparison between the averaged spectra acquired in the field and the spectral signatures recorded by HyMap for the respective pixels are demonstrated. For homogenous surfaces, like the asphalted road (Fig. 5.01, left bottom), highest correlations could be observed. In the vegetated fields, however, the spectrometer tended to observe slightly higher NIR reflectance compared to the HyMap measurements. This may be due to the strong heterogeneity of some cropped surfaces, with bare-soil corridors between the rows. Moreover, the difference in spatial representativeness between the field spectrometer measurements (roughly 3 m^2, i.e. 0.4 m x 0.4 m x 20, see section 7.1) and of the HyMap signatures (pixel size approximately 16 m^2) must be considered. Thus, the match between field and airborne spectra can be considered as very satisfying.

Conclusively, the data set can be considered as reliable data base of hyperspectral records to be used for further analyses and investigations such as the derivation of agricultural land surface variables.

The full comparison of all sample points acquired with the field spectrometer within the time of the HyMap overpass can be accessed in the appendix (10.4 – 10.6)

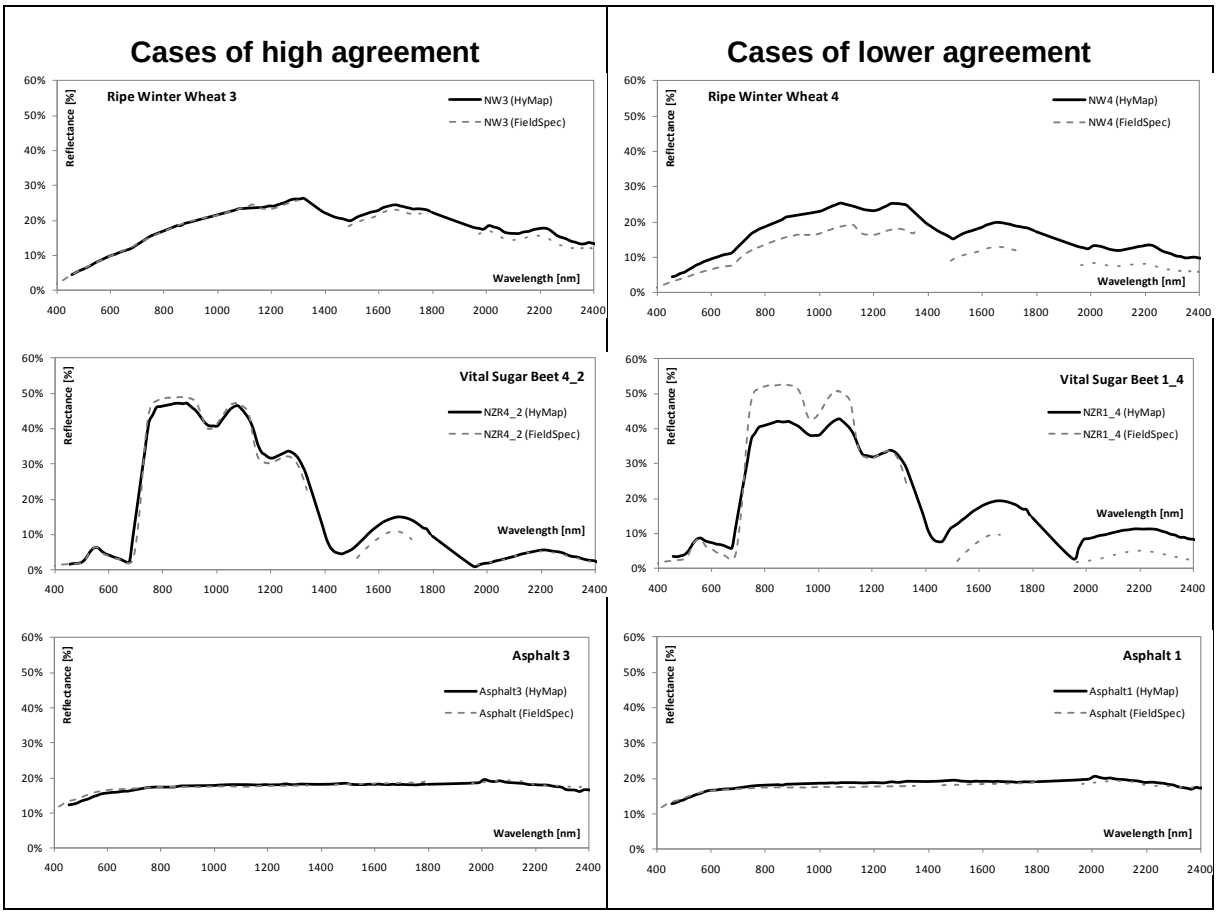

Figure 5.01: Comparison of spectra acquired with the airborne HyMap Scanner (solid) and a portable ASD FieldSpec3 JR (hatched) on July 27th 2009. For three different land cover categories the best (left) and the worst (right) cases of agreement between both sensors are presented.

6 Additional Data

6.1 Ground Radiometric Measurements

In order to control the quality of atmospherically corrected HyMap data sets, ground radiometric measurements were recorded concurrently with the airborne sensor overpass. The measurements were conducted by means of a handheld FieldSpec3 JR field spectro-radiometer (ASD), as specified in Table 6.01, at different targets. For most of the measurements a time window of +/- one hour enveloping the actual flight time could be arranged.

Table 6.01: Technical details of the instrument applied for the field spectroscopy measurements.

Manufacturer:	Analytical Spectral Devices, inc. (ASDi)
Type:	FieldSpec® 3 Jr. Full Range
Serial number:	16076
Version:	FS3 350-2500JR
FOV:	25°
Spectral range:	350 – 2500 nm
Spectral resolution:	3nm @ 700nm, 30nm @ 1400nm and 2100nm
Year of purchase:	01/2007
In operation since:	05/2007
Recent calibration:	December 20th 2006, Boulder, Colorado, USA

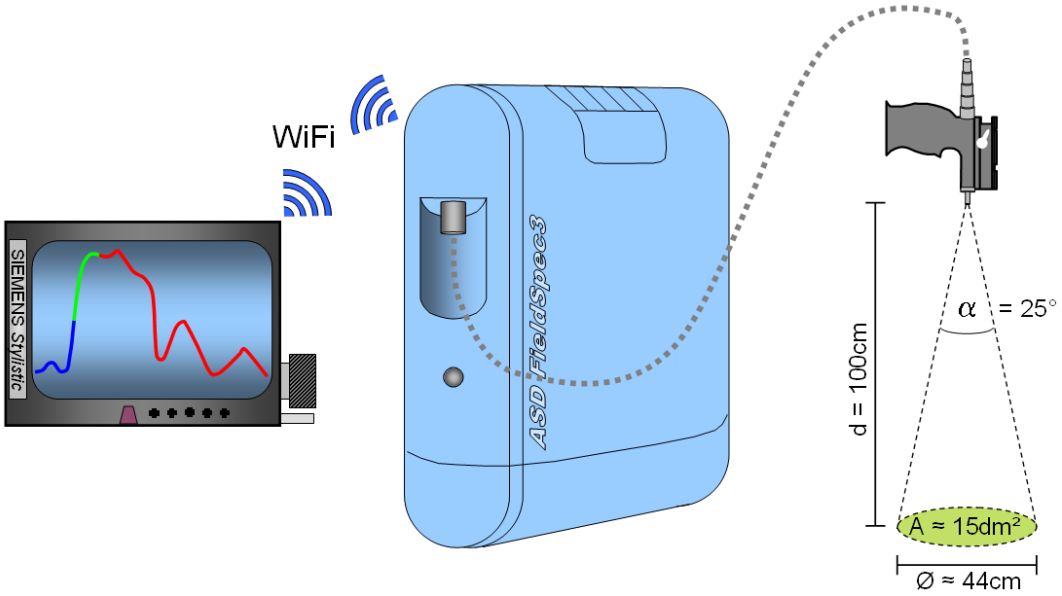

Figure 6.01: Basic recording geometry of the field spectrometer measurements, showing the wirelessly connected field tablet PC, the spectrometer and the fiber probe above the target.

During the measurements, the probe was positioned about 1 m above the target surface, resulting in a covered target area of approximately 0.15 m², due to the sensors FOV of 25° (see Fig. 6.01). Since the geometric resolution of the HyMap sensor (roughly 4 x 4 m) and the field spectrometer (roughly 0.4 x 0.4 m) differ largely and therefore limit the comparability of both spectral signatures, the field spectrometer measurements were designed to integrate over the small scale heterogeneities of the respective targets.

In order to compensate for the difference of the geometric resolution, the probe was moved across the target describing a semi-circle. For every target 20 spectral samples, each averaged from 10 single readings, were stored continuously (Fig. 6.02).

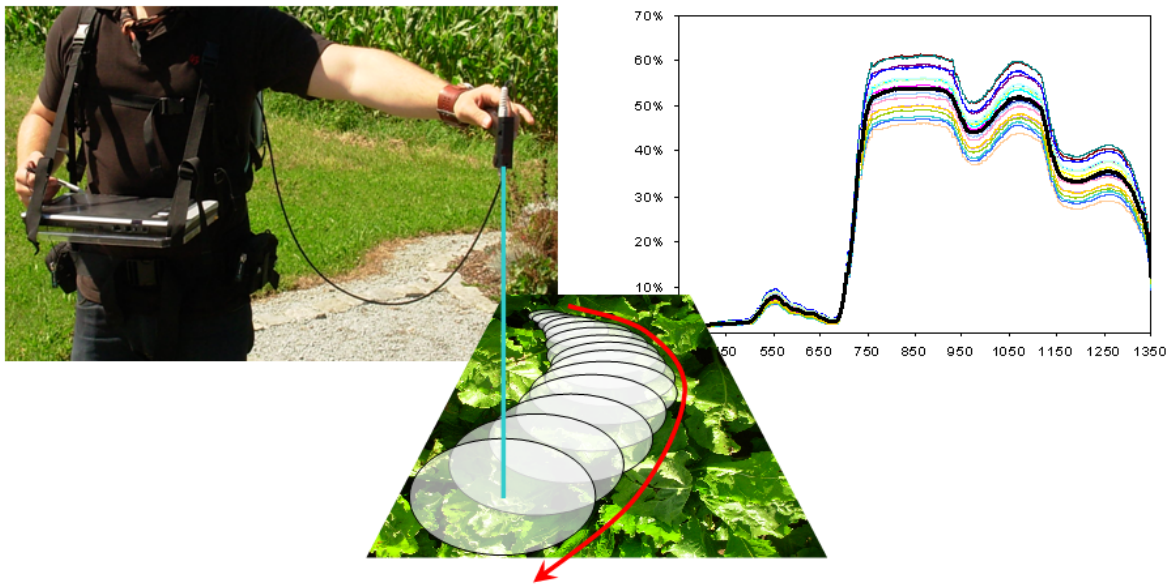

Figure 6.02: Semi-circle sampling design of the field spectrometer measurements, integrating over the target heterogeneities and thus compensating for the difference in geometric resolutions between the field spectrometer and the HyMap sensor.

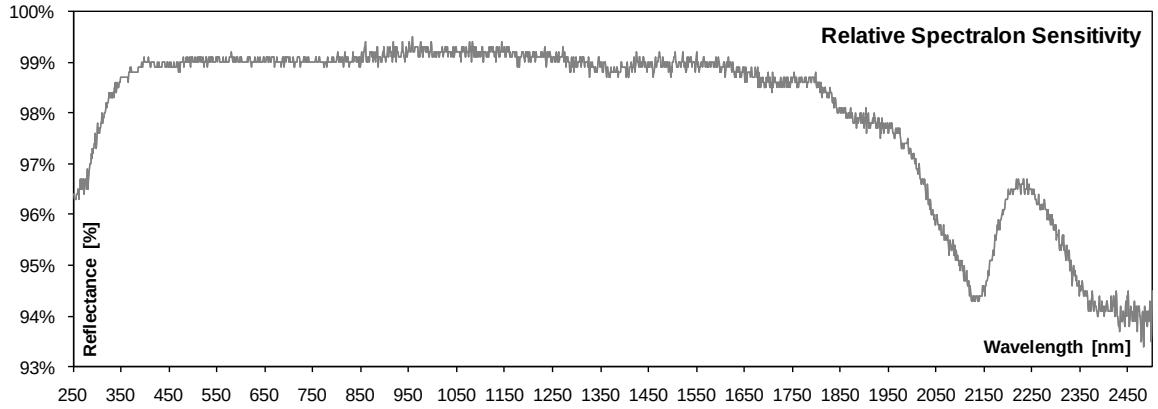

Figure 6.03: Spectral response of the calibrated spectralon reflectance standard that was used for the conversion of field spectrometer measurements to absolute reflectance.

The signal recorded by the different detectors of the spectrometer may show jumps at 1000 nm and 1800 nm due to the different FOV of the single optical fibers within the probe (detector splice). Thus, as part of the post-processing, the measurements were corrected additively using the fist silicon-based detector as reference signal.

The continuous spectra were then converted into absolute reflectances using the response curve of a calibrated LabSphere Spectralon® reference panel (Fig. 6.03). In total, 27 averaged spectra from three different land cover categories could be acquired. The spectral domains from 1350 nm to 1500 nm and from 1800 nm to 1950 nm were masked in order to eliminate the distortions due to atmospheric water vapor (see Fig. 6.04).

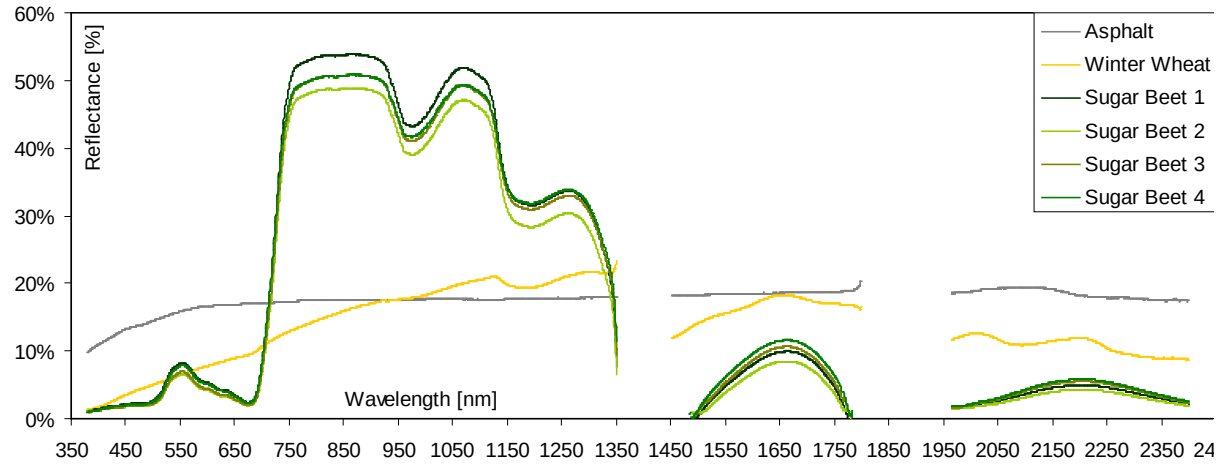

Figure 6.04: Average spectral signatures of three different land covers (asphalt, ripe winter wheat, sugar beet), recorded with an ASD FieldSpec3-JR during the HyMap overflight.

6.2 In-situ Measurements of Land Surface Variables

The main task of the universities invited to join the EnMAP preparation project consisted in the generation of a rich ground observation database for validation of biophysical products derived from the remote sensing airborne acquisitions. Therefore, the LMU Munich concentrated on applying well established field sampling techniques to collect a high number of measurements mostly parallel to the sensor overpass.

The ground measurement campaign was designed of two parts, being independent to some extent. One part was considered to be highly sensitive with respect to the time of the measurements (i.e., spectroscopy, soil moisture etc.). The other part of the proposed measurements was supposed to be less temporally sensitive (i.e., land use mapping, LAI sampling etc.).

In the following sub-sections land cover mapping and performed measurements of the biophysical variables are described in detail.

6.2.1 Generation of a Land Cover Map

Based on digital orthorectified aerial images, which were kindly provided by the Bavarian Land Survey Agency free of charge, basic geometric features of the proposed test areas were digitized using ESRI ArcMap 9.3. According to the digital substructure, a Gauß-Krüger zone 4 (Bessel, Potsdam) projection was used for the original digitizing process. The polygonal geometries were later reprojected to UTM (WGS 84) in order to match the cartographic projection of the HyMap data sets. Since the spatial coverage of the orthophoto product did not satisfy the whole test area, Landsat imagery from 2003 was used to extend the base map. The basic information consisting in the polygonal geometry, aerial orthophotos and Landsat imagery was printed on several DIN A3 cardboards to serve as orientation guide for the ground teams (Fig. 6.05).

Figure 6.05: The original land cover documents of the test sites Neusling (left) and Steinbeißen (right).

The task of mapping the actual land cover into the prepared GIS-polygons was performed by two independent teams, who recorded the on-site land cover information manually, as documented in figure 6.06. Allowing for a quick survey, a three digit land cover code was used to identify the different agricultural and natural land cover categories (see Appendix 10.7).

Figure 6.06: Student assistant Mrs. Theresa Brandlhuber is entering the land cover classification code onto a hardcopy of an aerial ortho-photograph (left). Student assistant Mr. Georg Fischer verifies the observations roughly made from the inside of the car through a closer investigation of the crops in the field (right).

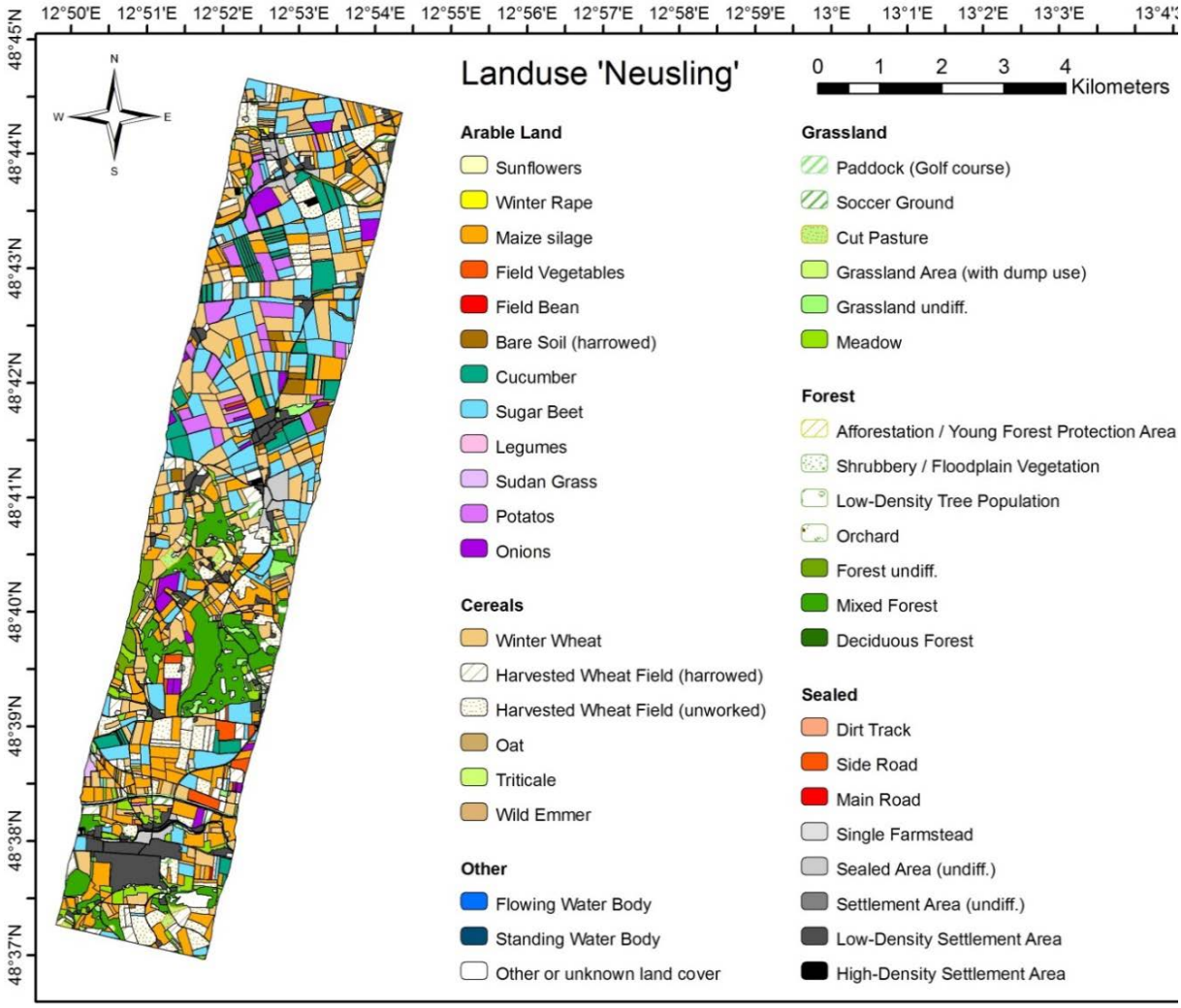

Figure 7.07: Fully detailed land cover map of the test site Neusling, status 27th of July 2009.

Thanks to those endeavors, two very detailed land cover maps could be generated, one for each test site (Figs. 6.07 and 6.08). The maps do not only identify the current land cover, but also indicate for several cases the current management state of individual fields (i.e. harrowed, harvested etc.). Thus, information dating more or less from the time of the sensor overpass is provided, which is a crucial prerequisite for digital image interpretation.

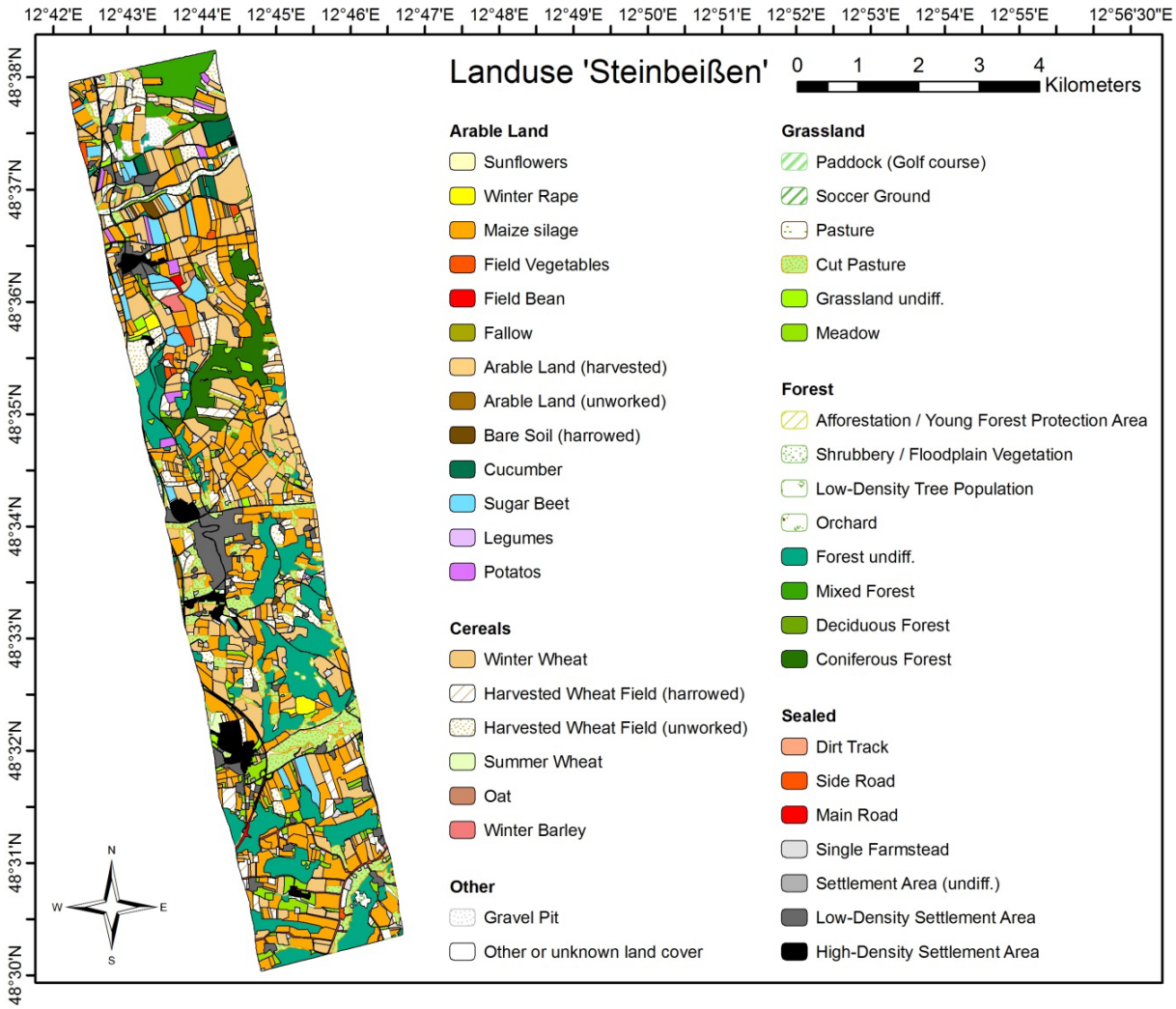

Figure 6.08: Fully detailed land cover map of the test site Steinbeißen, status 27th of July 2009.

6.2.2 Determination of Land Surface Variables

6.2.2.1 Design and sampling scheme of the measurements

Whereas the land cover mapping was carried out for the whole HyMap coverage, detailed biophysical measurements were performed at selected sample fields, located within the two test areas (Table 6.02). The selection of winter wheat, maize and sugar beet as sample crops ensures certain variability in the data set, which can be used in further analyses to test the robustness of existing and new retrieval algorithms.

First of all, an appropriate field data sampling strategy must be defined. This is one of the most critical issues when performing ground measurements to be used for validation of remotely sensed estimates (e.g., Martinez et al., 2009). For this purpose, Elementary Sampling Units (ESU) are defined beforehand, corresponding either to the spatial resolution of the used remote sensor or to clearly recognizable patterns, like single fields. The sampling strategy within each ESU has to assure that the measurements represent the spatial variability of the observed variables. Number of measurements and design of the sampling scheme depend, amongst others, on the heterogeneity of the area (i.e., the crop field) and the dimensions of the ESU (Martinez et al., 2009).

Table 6.02: Selected test fields within the two test areas of the 2009 HyMap campaign.

Neusling		Steinbeißen	
Test Field	**Crop**	**Test Field**	**Crop**
NW	Winter Wheat	LP1	Winter Wheat
NM	Maize	LP2	Winter Wheat
NZR1	Sugar Beet	LP3	Sugar Beet
NZR2	Sugar Beet	S2	Sugar Beet
NZR3	Sugar Beet	S4	Maize
NZR4	Sugar Beet	S6	Maize

The following sampling scheme was designed for the biophysical measurements of the actual campaign: in every test field (i.e., ESU), five measurement points were defined, one in every corner and a fifth in the middle of the field, thus creating an equally distributed sampling pattern for each test site (Fig. 6.09, right). In order to avoid measurement errors due to 'border effects', which may be caused by the entirely different management in the field's headland, an adequate distance of at least 2 m (depending on the characteristics of the field) was kept from the sampling points in the corners to the field boundary. The sampling points were pre-selected from aerial photographs and located in the field using handheld GPS receivers of the type Garmin eTrex (Fig. 6.09, left).

This number of measurements in each field should be seen as a compromise between the minimum sample size to fulfill the requirements of a representative ESU, and the limited time window of flight-parallel measurements.

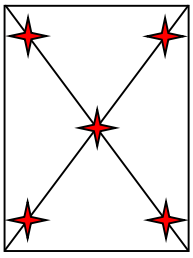

Figure 6.09: GPS positioning of sampling points (left) and general pattern for the positioning of sampling points within a test field (right).

In addition to the detailed measurements within the selected test fields, soil moisture content, phenology and canopy height were monitored along measurement transects in each test area (i.e., in each HyMap-scene).

6.2.2.2 Determination of aboveground biomass and canopy water content

In order to determine the wet and dry aboveground biomass of different crops, destructive measuring techniques were applied shortly after the image acquisition. First of all, the stand density was measured for each sample point by counting the number of individual plants along 2 m of a sowing track and by averaging the distance between the parallel sowing tracks, thus allowing for an extrapolation of the plant density.

Figure 6.10: Student assistant Mr. Jochen Scholtes is determining plant density in a field of winter wheat (left), while his colleague, student assistant Mrs. Annamaria Rittger, enters the measurements into specially designed data forms (right; an example of the data forms is given in the Appendix 10.8).

For the actual biomass sampling, three plants along one sowing track were cut directly above the ground on each sampling point. The plant parts were then neatly packed into waterproof plastic bags in order to preserve the inner humidity of the sample. All samples were weighted on a high precision laboratory scale in the field almost directly after the cutting, thus avoiding the loss of water vapor during transport. The final fresh weight was then determined according to equation 6.01 by multiplying the average weight of three single plants (subtracting the weight of the bags/container) with the density of the stand.

$$FreshMass\,[g \cdot m^{-2}] = \left(\frac{WetSampleWeight\,[g] - ContainerWeight\,[g]}{3\,[plants]} \right) \cdot \mathrm{StandDensity}\left[plants \cdot m^{-2} \right] \qquad (Eq.\ 6.01)$$

In total, 58 measurements of aboveground biomass could be acquired on the actual day of the sensor overpass, covering maize, sugar beet and winter wheat. An overview of crop-specific measurement results (mean and standard deviations) is given in Figure 6.11.

Winter wheat and maize naturally show higher accumulations of aboveground biomass compared to root vegetables such as sugar beet (see Fig. 6.11). The complete list of measured values for all sample points of the selected test fields can be accessed in full detail in the appendix (10.9 – 10.10).

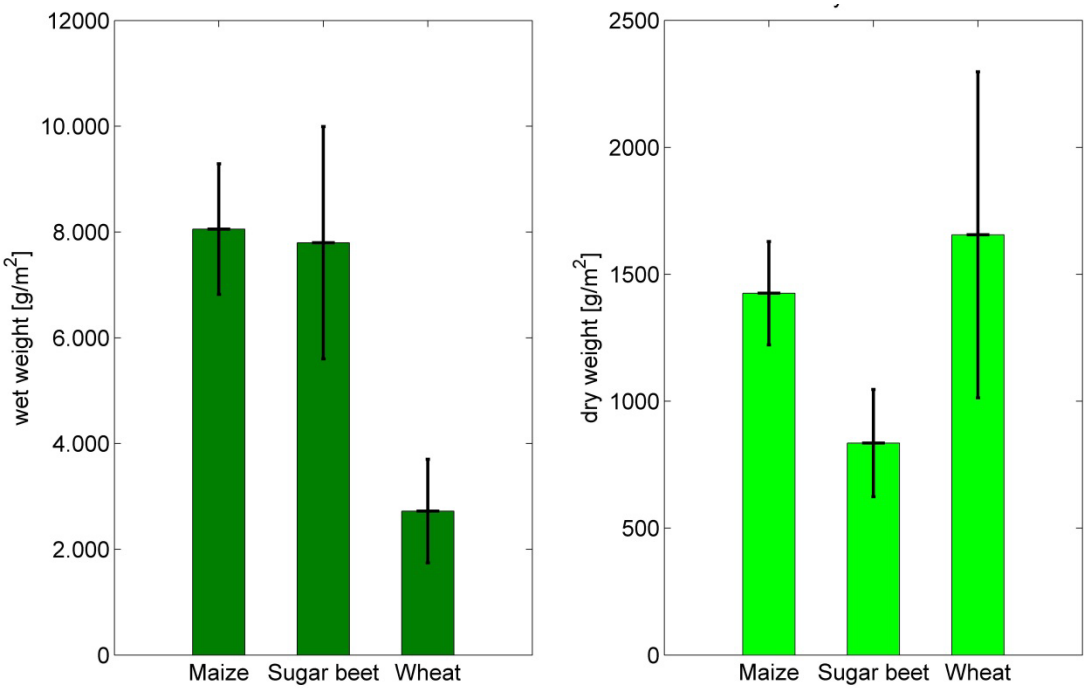

Figure 6.11: Crop specific results of measurements of wet and dry biomass, green bars represent means of measurements (N): maize: 13, sugar beet: 30 and wheat: 15 (standard deviation indicated with black bars).

After the wet samples of fresh aboveground biomass had been transported to the LMU laboratory, they were manually disaggregated to allow for a thorough drying process (Figs. 6.12 and 6.13).

Figure 6.12: Fractioning and preparation of the fresh vegetation samples in the LMU plant physiological laboratory.

Following a confirming check of the wet weight, the samples were dried for at least 24 hours at 85 °C in a drying oven with a constant air supply.

Figure 6.13: Fresh samples of sugar beet leaves, before drying, in the LMU plant physiological laboratory.

When the samples were thoroughly dry the weighing was repeated (Fig. 6.14), and the final dry biomass was calculated following equation 6.02.

$$DryMass\,[g \cdot m^{-2}] = \left(\frac{DrySampleWeight\,[g] - ContainerWeight\,[g]}{3\,[plants]} \right) \cdot \mathrm{StandDensity}\left[plants \cdot m^{-2} \right] \qquad (Eq.\ 6.02)$$

Figure 6.14: After drying, the samples were taken from the oven (left) and the dry mass was determined on a laboratory scale (right).

Figure 6.15 shows the spatial distribution of the dry aboveground biomass as recorded during the flight campaign day.

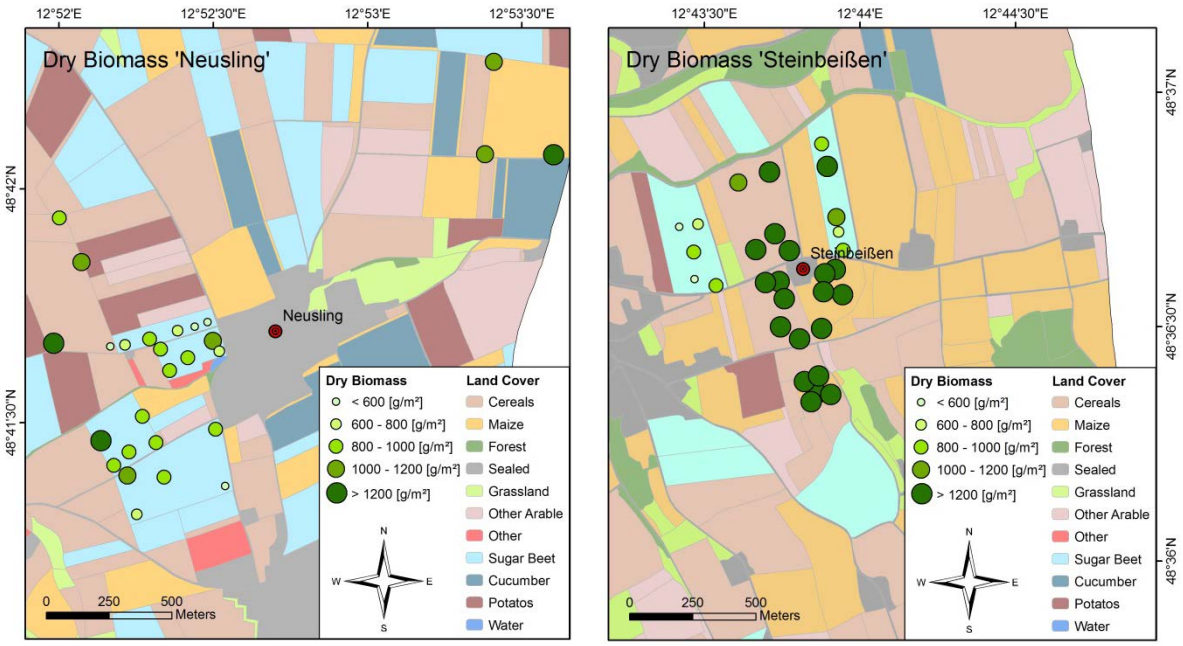

Figure 6.15: Dry biomass sample points of the area Neusling (left) and Steinbeißen (right), derived from destructive measurements on July 27th 2009.

The canopy water content, or canopy equivalent water thickness (EWTc; e.g., Colombo et al., 2008), is calculated as the difference between fresh (wet) weight and dry weight (Eq. 6.03).

$$\mathrm{EWT_c}\,[g \cdot m^{-2}] = WetWeight[g \cdot m^{-2}] - DryWeight[g \cdot m^{-2}] \qquad (Eq.\ 6.03)$$

According to the sampling of biomass, 58 measurements of canopy water content were acquired on the actual day of the sensor overpass (Fig. 6.17), covering the crops maize, sugar beet and winter wheat. Figure 6.16 shows the mean values and standard deviations of the crop-specific measurements.

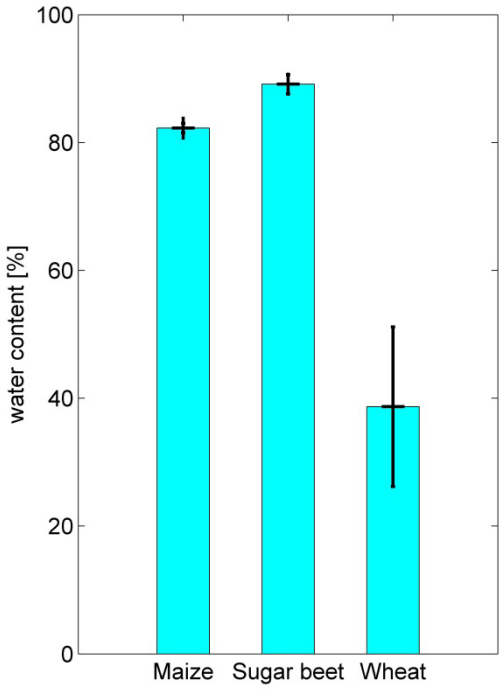

Figure 6.16: Crop specific results of canopy water content measurements (EWT_c), blue bars represent means of measurements (N): maize: 13, sugar beet: 30 and wheat: 15 (standard deviation indicated with black bars).

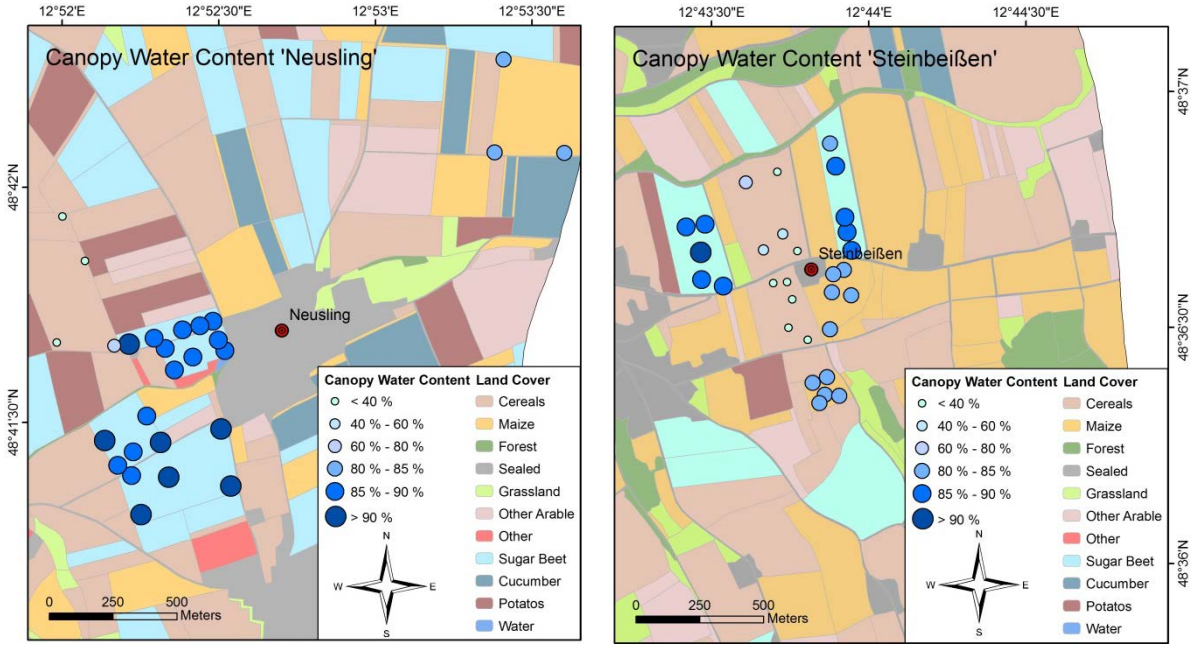

Figure 6.17: Canopy water content (EWT_c) of selected sample points of the area Neusling (left) and Steinbeißen (right), derived in the LMU laboratory from destructive measurements on July 27th 2009.

6.2.2.3 Leaf Area Index (LAI) measurements

The leaf area index (LAI) - defined as the one-sided area of photosynthetic tissue per unit ground surface area (Watson, 1947) - was measured in both test areas with two LI-COR LAI-2000 (LI-COR, Inc., Nebraska, USA). With this instrument, indirect and non-destructive estimates of LAI are collected, allowing for frequent measurements over large areas.

The optic of the LAI-2000 is composed of a fish eye lens (148° of field of view) that detects the radiation transmitted through the canopy in five zenith angles centered at 7°, 23°, 38°, 53° and 68° (Fig. 6.18). The estimation is based on a gap fraction method determining LAI by a simple radiative transfer model inversion (Martinez et al., 2009). Further details of the measurement procedure can be found in the LAI-2000 user manual (Welles and Cohen, 1996). The measuring technique combines a measurement above the canopy with several measurements beneath the canopy, while the sensor is orientated skywards.

For further analyses of the data it has to be considered that due to its measurement principle, the sensor does not distinguish photosynthetically active leaf tissue from other plant elements, such as stems, flowers or senescent leaves. Moreover, the clumping effect, i.e. non-random positioning of canopy elements, is neglected. Thus, the here measured 'LAI' corresponds to the effective PAI ('PAIe') (Garrigues et al., 2008).

Four below-canopy measurements were taken to achieve an average for every sampling point, corresponding to the minimum recommendations of the LI-COR manual (Welles and Cohen, 1996). In order to reduce measurement uncertainties, a higher number of below-readings or some repetitions of the cycle may have been required. However, available time, instruments and staffing situation were restricted. Measurements were taken under diffuse radiation conditions, i.e., avoiding direct sun. To exclude the effect of horizontal shielding through the operator, the instrument was operated using a 180° view restrictor. Moreover, below- and above-canopy measurements were carried out at identical heights and azimuth directions.

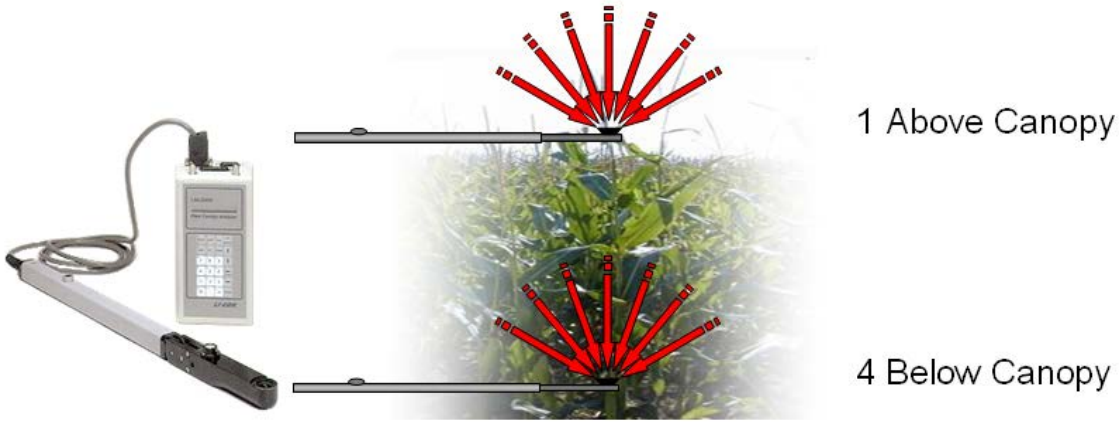

Figure 6.18: Principle of leaf area index measurements with the LI-COR LAI-2000 instrument.

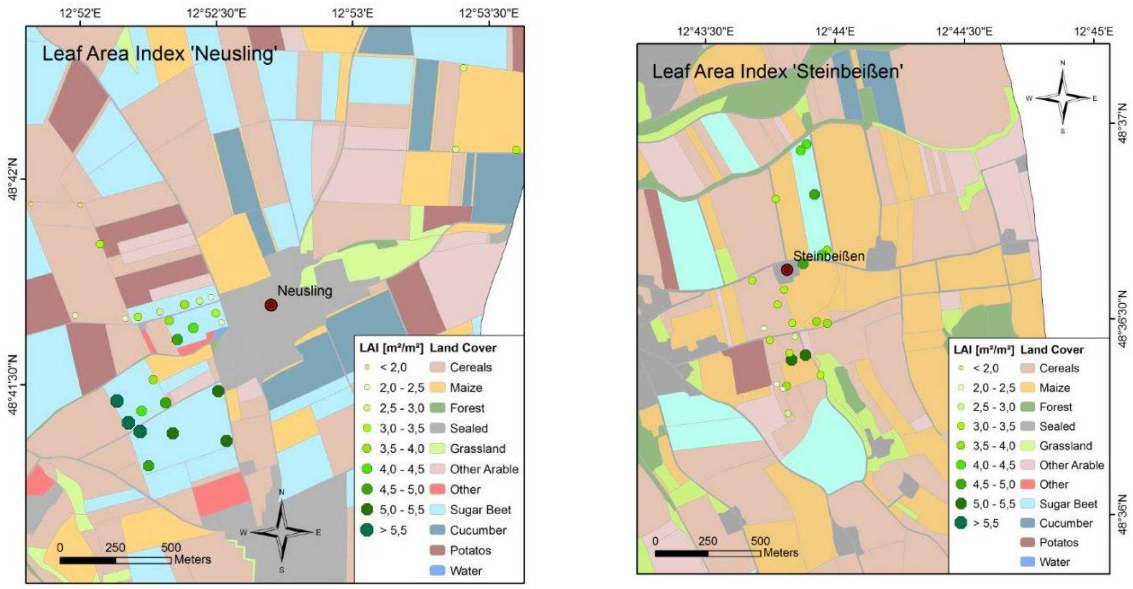

Figure 6.19: Leaf area index measured using the LI-COR LAI-2000 instrument during the ground measurement campaign on 27th of July 2009 for the two test sites 'Neusling' (left) and 'Steinbeißen' (right).

Standard deviations of the resulting measurements were kept as measure of uncertainty. In Figure 6.20, mean (and standard deviations) of the crop-specific measurements are shown. Due to technical difficulties with the LICOR LAI probes, only 52 measurements could be acquired on the day of the HyMap acquisition, covering 3 different crop types (Fig. 6.19). Even though the output of the LAI collection is considered as satisfying, the measurement protocol should be optimized for upcoming campaigns.

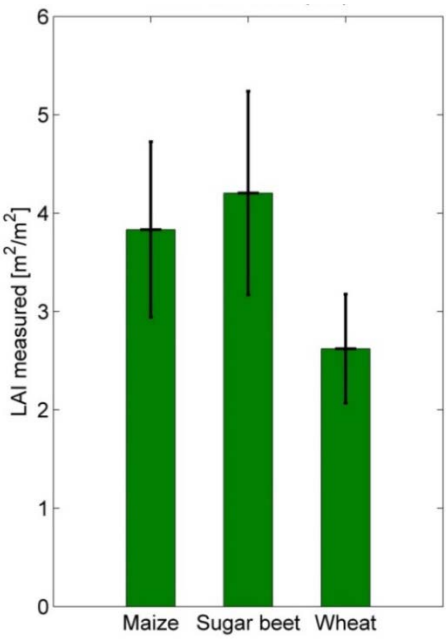

Figure 6.20: Crop specific results of leaf area index measurements (LAI), green bars represent means of measurements (N): maize: 11, sugar beet: 25 and wheat: 16 (standard deviation indicated with black bars).

6.2.2.4 Soil moisture measurements

The soil moisture content was determined volumetrically using ThetaProbes of the type ML2x. The probes are manufactured by Delta-T Devices, Cambridge (http://www.delta-t.co.uk/) and are distributed via UMS, Munich (http://www.ums-muc.de/). A brief description of the operating principles is given below according to Topp & Ferre (2005) and Miller & Gaskin (2009).

The ThetaProbe measures volumetric soil moisture content, θv, applying the well-established method of responding to changes in the apparent dielectric constant. These changes are converted into a DC voltage, virtually proportional to soil moisture content over a wide working range. ThetaProbes consist of a waterproof housing containing the electronics, and four sharpened stainless steel rods attached at one end that have to be inserted into the soil (Fig 6.21, left). The probe generates a 100 MHz sinusoidal signal, which is applied to a specially designed internal transmission line that extends into the soil by means of the array of four rods. The impedance of this array varies with the impedance of the soil, which has two components - the apparent dielectric constant and the ionic conductivity. The 100 MHz signal frequency has been chosen to minimize the effect of ionic conductivity, so that changes in the transmission line impedance are almost solely dependent on the soil's apparent dielectric constant. Because the dielectric constant of water (~81) is much higher than of soil (typically 3 to 5) and air (1), the dielectric constant of soil is primarily determined by its water content.

Figure 6.21: ThetaProbe ML2x (User Manual, page 3, left) and student assistant Mr. Jochen Scholtes, calibrating the ThetaProbe in the middle of a sugar beet field (right).

The impedance of the rod array affects the reflection of the 100 MHz signal, and these reflections combine with the applied signal to form a voltage standing wave along the transmission line. The output of the ThetaProbe is an analogue voltage proportional to the difference in amplitude of this standing wave at two points, and this forms a sensitive and precise measurement of soil moisture content. The accuracy of the devices with the used standard calibration is 5 vol. % (Delta-T Devices, 1999).

During the field campaign soil moisture was measured at least 5 times at every sampling point to obtain a representative estimate of the real soil moisture. The soil moisture for every sampling point is determined from these measurements by calculating the arithmetic average. Given the geometry of the probes, the explored soil depth was less than 5-6 cm from the surface. In total, 250 measurements

of average soil moisture could be acquired during the day of the sensor overpass, covering the main land cover types of the area (Fig. 6.22).

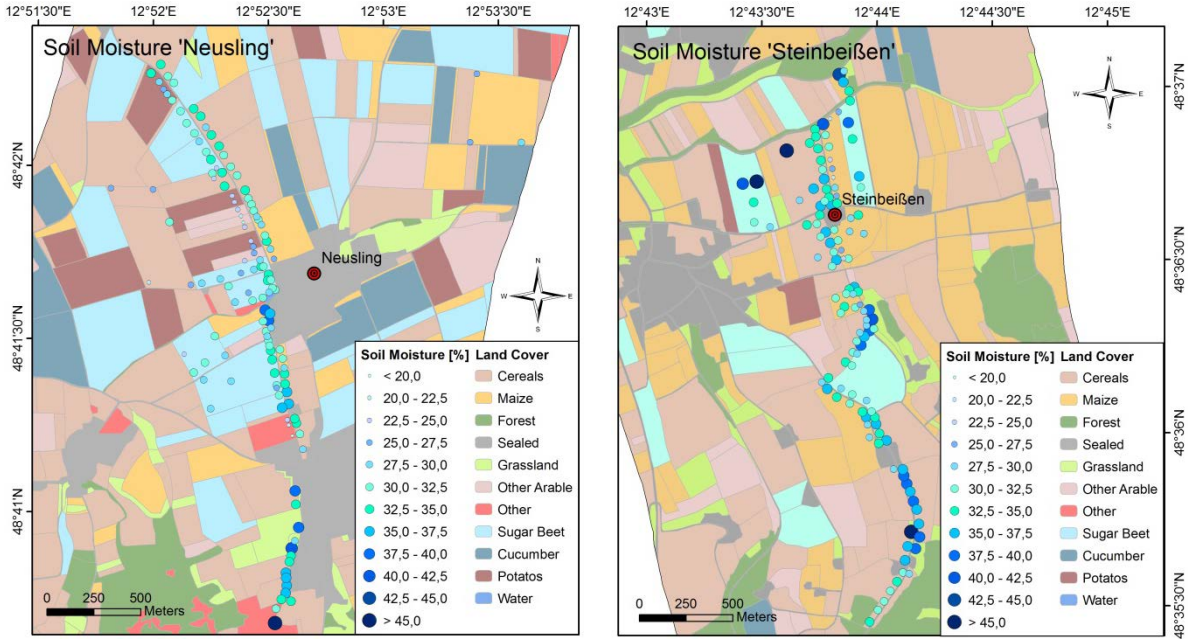

Figure 6.22: Average soil moisture as measured using Delta-T ThetaProbes during the ground measurement campaign on 27th of July 2009 for the two test sites 'Neusling' (left) and 'Steinbeißen' (right).

Figure 6.23 demonstrates specific measurements (mean and standard deviations) for the 16 different land cover classes monitored.

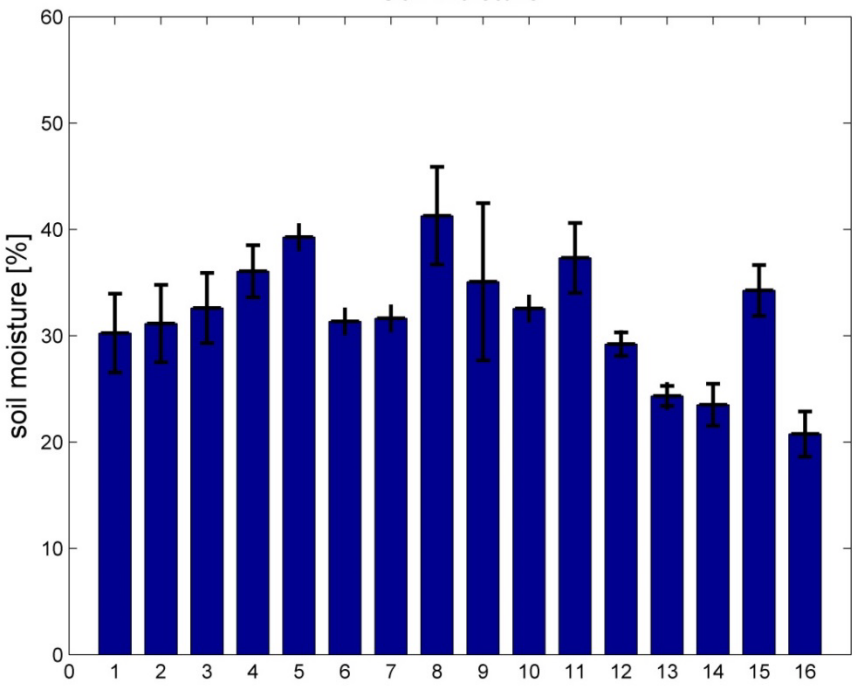

Figure 6.23: Land surface specific results of soil moisture measurements, blue bars represent means of measurements: (1) maize: N = 51, (2) sugar beet: N = 59, (3) wheat: N = 73, (4) bare soil (N = 16), (5-11) different types of grassland and meadow, N = 19, (12) oat, N = 5, (13) onion, N=2, (14) potatoes, N = 10, (15) Rye, N = 12, (16) unknown, N = 3 (standard deviation indicated with black bars).

6.2.2.5 Determination of canopy height

The height of the canopy was only determined for the uppermost canopy level (depending on the crop either shoot or leaf level) by applying a simple folding rule (Fig. 6.24, left). On every sampling point, a set of ten measurements was averaged in order to generate a robust mean (Fig. 6.24, right).

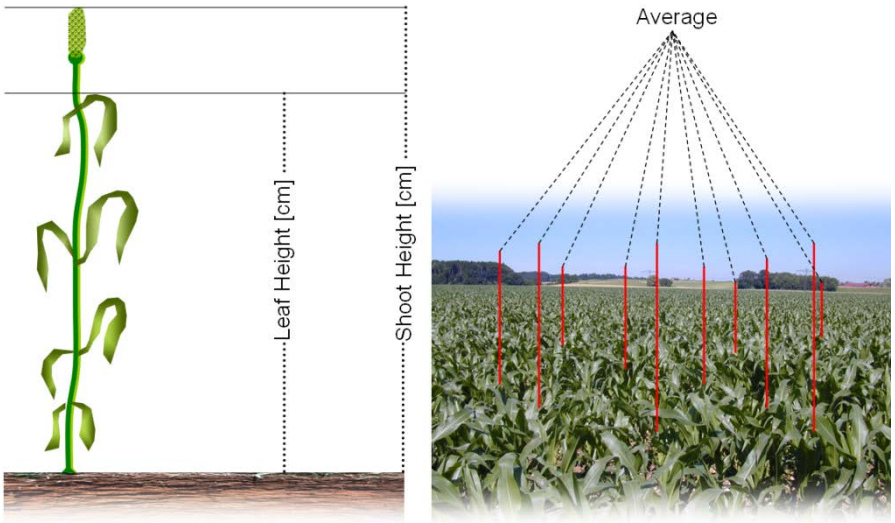

Figure 6.24: Principle of measuring the height of a canopy in the field.

In total, 249 observations of average canopy height were collected during the campaign, covering 14 different agricultural land cover categories. Figure 6.25 shows the resulting spatial distribution of the height measurements.

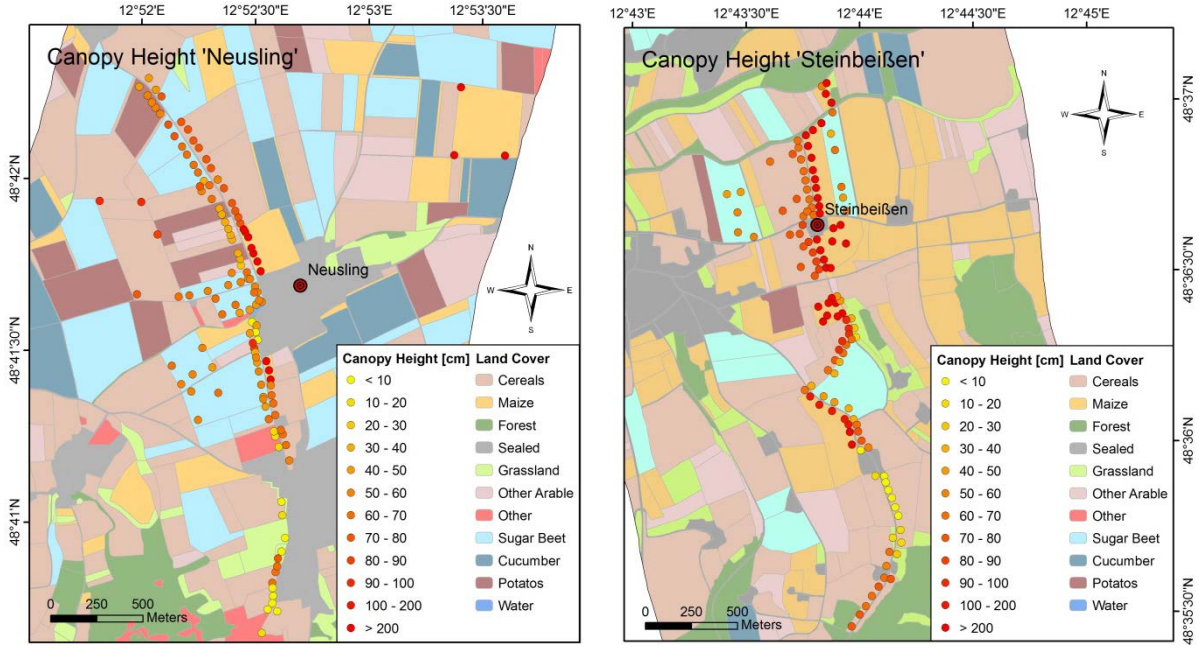

Figure 6.25: Canopy height measurements during the campaign on 27th of July 2009 for the two test sites 'Neusling' (left) and 'Steinbeißen' (right).

6.2.2.6 Phenological categorization

Being an important indicator for the interpretation of hyperspectral readings, the phenological development of the test sites was monitored according to the internationally recognized BBCH-Code (Federal Biological Institute – Federal Bureau of Species - Chemical Industry, Biologische Bundesanstalt für Land- und Forstwirtschaft 1997). The classification system categorizes the growth stages of different crops by applying a decimal code, ranging from 0 (sowing) to 99 (ripeness, harvested, Fig. 6.26).

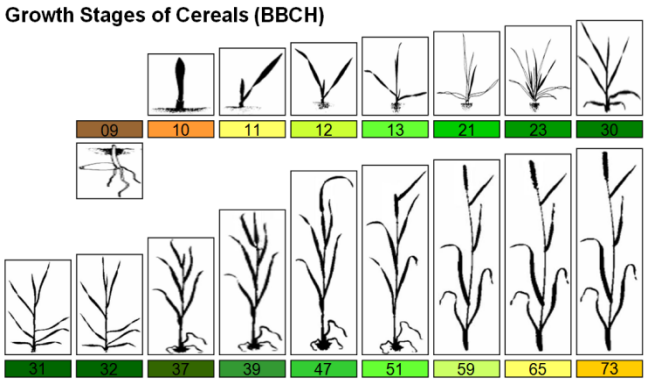

Figure 6.26: Decimal code of BBCH growth stages with their corresponding observable features. Modified after BIOLOGISCHE BUNDESANSTALT FÜR LAND- UND FORSTWIRTSCHAFT (1997).

By comparing detailed descriptions and images of the BBCH classification system with observable aboveground features of the investigated crops, the accurate determination of the current growth stage can be accomplished with reliable precision by an experienced operator. A total of 199 observations of plant phenology were recorded on seven different agricultural crop types during the campaign as shown in Figure 6.27.

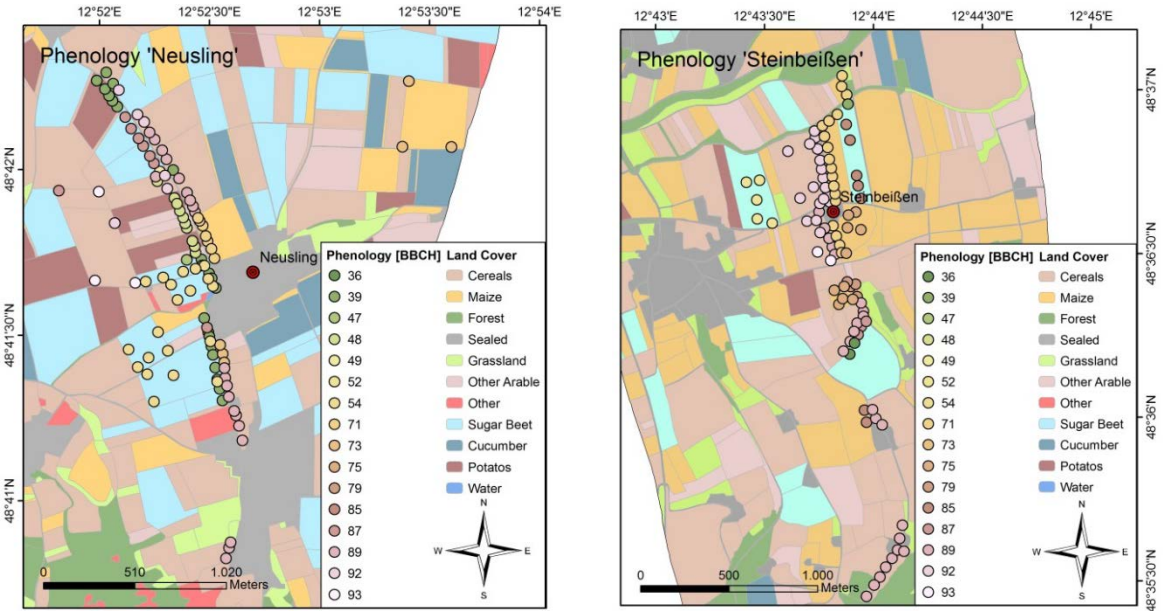

Figure 6.27: Plant phenological growth stages according to the BBCH classification system as observed during the ground measurement campaign on 27th of July 2009 for the two test sites 'Neusling' (left) and 'Steinbeißen' (right).

6.2.2.7 Digital photographs

Each sample point was intended to be documented by two digital photographs. A NIKON Coolpix L101 camera (6.2 Megapixels) was used to record a horizontal and a vertical shot of each sampling point. For most of the sample points within maize stands no vertical pictures could be acquired, since the plants well exceeded two meters of height. In order to allow for a later derivation of leaf angle distributions, the horizontal pictures were taken using a gridded background, featuring a grid cell size of 5 x 5 cm (Fig. 6.28, right). In total 270 digital images were taken on the day of the sensor overpass, documenting the sample points and the progress of the campaign activities.

Figure 6.28: Example for horizontal (left) and vertical (right) photographic documentation of the sample points of sugar beet (top) and winter wheat (bottom).

7 Dataset Contact

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10 Appendix

10.1 Study area

10.1.1 Geology and Geomorphology

Both test sites are characterized by abrupt changes from rather flat to undulating terrain (Fig. 10.01). The reasons for these morphological disturbances can be found in the evolutionary history of the region. The area is situated on tertiary sediments (Upper Freshwater Molasse) with quaternary Loess accumulations in the north-east of the 'Tertiärhügelland', around 10 km south-west of the low mountain range of the Bavarian Forest. Neusling is situated between the river valleys of Isar, Donau and Vils on a terrace with low relief energy.

The HyMap scene, successfully acquired in the context of this project above the Neusling test site (for details see section 2), extends from the northern rim of the terrace (~320 m asl), about 1 km east of the river Isar, over the terrace itself and some hills at the southern end of the terrace (~420 m asl) into the Vils valley. The centre of the second test site, the village Steinbeißen, again is situated in the southern part of the Vils valley, where the Loess cover is generally less pronounced. Near the actual riverbed of the Vils, quaternary alluvial sediments are dominating the landscape. The HyMap acquisition extends here from the flat Vils valley (374 m asl) into the south over hilly terrain (460 m asl) to the Unterfailnbach valley (Fig. 10.01).

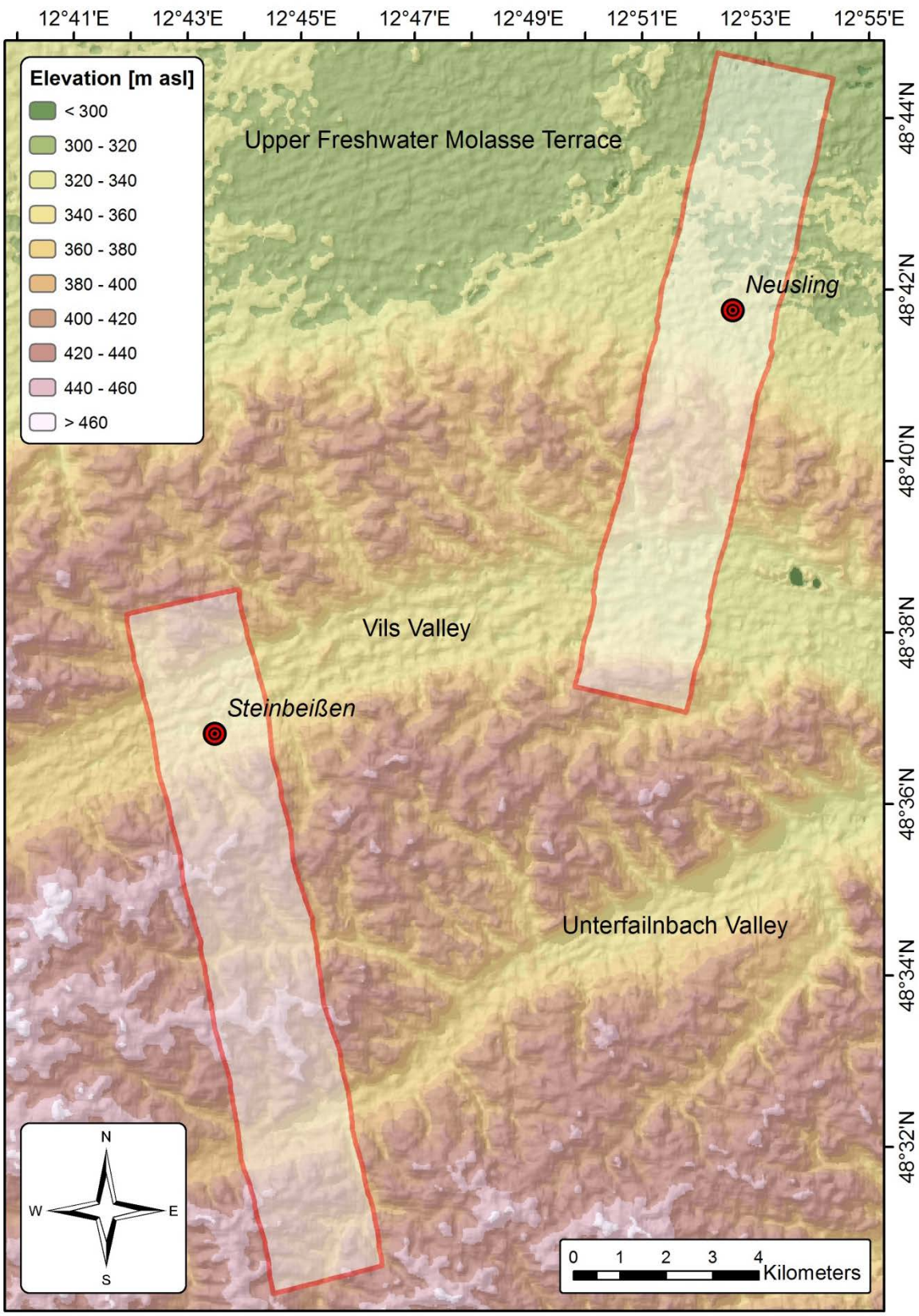


Figure 10.01: Geomorphologic map generated from ASTER digital elevation data, showing the relief of the two test sites 'Neusling' and 'Steinbeißen' as it is formed by the Danubian tributaries. The highlighted areas indicate the actual extent of the two HyMap acquisitions.

10.1.2 Climate

The climate of the considered area shows the typical characteristics of a seasonal climate zone. A temperature maximum in July and a minimum at the end of January are indicating a temperate continental climate. According to the genetic 'Flohn' classification, the area is categorized as a transition climate of the extra tropical zone of Westerlies (Flohn 1971). Following the effective 'Köppen and Geiger' classification system (Köppen 1936), the region is assigned to the Cfb-climate zone, indicating a cool, ever moist and temperate climate. Applying another effective global classification system following 'Troll and Paffen', the region falls into the category of moderately cool climates. It is represented by the III3 climate zone, which describes a sub-oceanic transition climate with annual temperature amplitudes of 16 to 26 K and mild and moderately cool winters respectively, the coldest month not falling below an average temperature of -3 °C. The precipitation maximum occurs in the summer season, which is characterized by moderately warm temperatures and by a relatively long duration. The average vegetation period is supposed to last more than 200 days per year (Troll and Paffen 1964).

This rough classification is confirmed through the long-term measurements of the weather stations (Table 10.01).

Table 10.01: Basic parameters of the two weather stations of the Bavarian agrometeorological network characterizing the two different test sites.

	Station 'Neusling	**Station 'Steinbeißen'**
Easting [geog.]:	12°52'36"	12°43'58"
Northing [geog.]:	48°41'40"	48°36'31"
Elevation [m asl]:	345	380
Long-term air temperature [°C]:	8	7 - 8
Long-term precipitation [mm/a]:	750 - 800	700 - 800
Landscape unit:	Eastern Dungau, moderately humid.	Lower Bavarian Tertiary Hill country, warm, rich loess.

Whereas the 'Neusling' station reports 8°C long-term average air temperature and 750 – 800 mm of precipitation per year, the 'Steinbeißen' station with 7° - 8°C is slightly colder with precipitation between 700 and 800 mm per year (see Table 10.01). The following figures show the meteorological conditions as they were recorded at the two meteorological stations 'Neusling' (Fig. 10.02) and 'Steinbeißen' (Fig. 10.03) throughout July 2009, directly before and during the actual ground measurement campaigns.

On July 5th 2009 an extreme rainfall event occurred in Steinbeißen with 81.7 mm of precipitation in one hour. The precipitation sum in July was 238.5 mm in Steinbeißen, while in Neusling only 97.4 mm of rainfall were recorded. This can be taken as an indicator for the determinant impact of the terrain situation on local climate conditions and the occurrence of local thunderstorms.

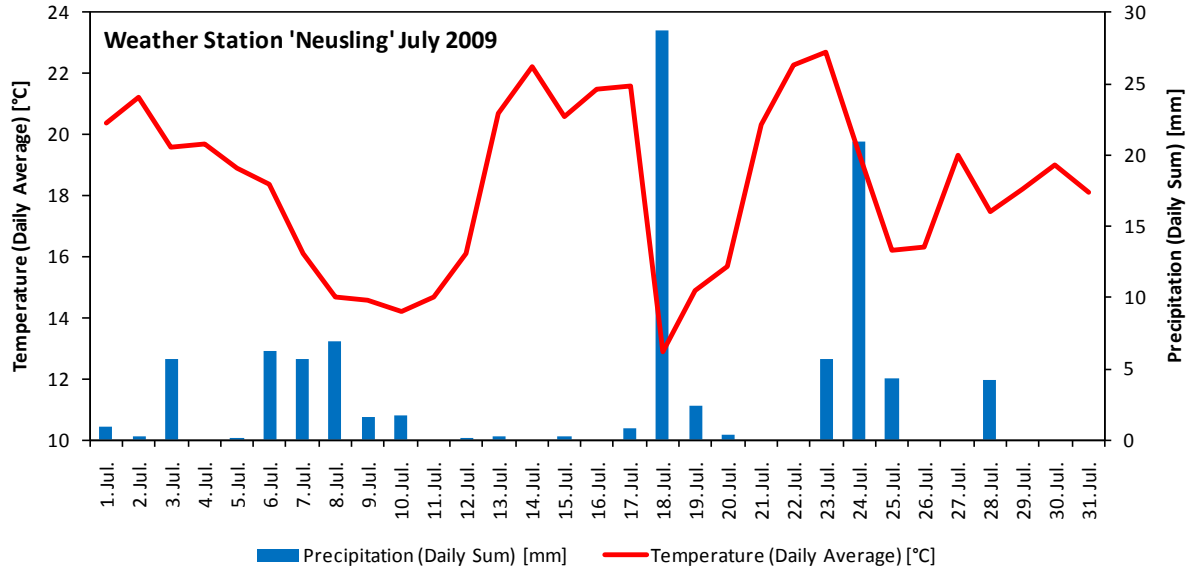


Figure 10.02: Daily measurements of air temperature and precipitation recorded during July 2009 by the agrometeorological weather station 'Neusling'.

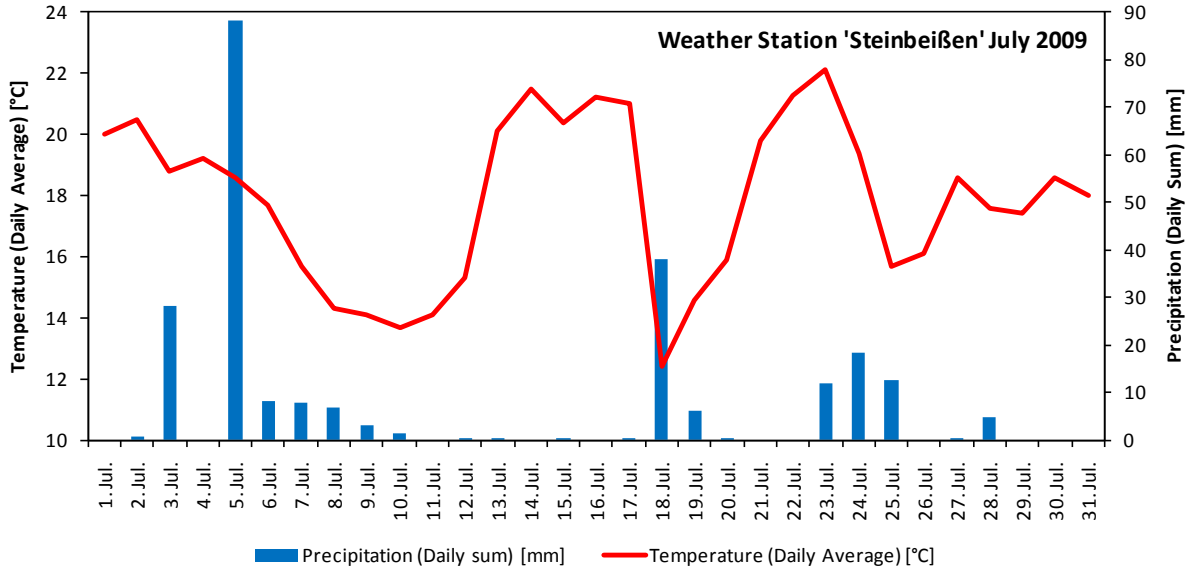


Figure 10.03: Daily measurements of air temperature and precipitation recorded during July 2009 by the agrometeorological weather station 'Steinbeißen'. The precipitation scale has been adjusted here to show the impact of the extreme rain event on the 5th of July 2009 with 88 mm during a single day.

10.1.3 Hydrology

Within the Neusling test site hardly any open water bodies exist apart from the river Vils at the southern end of the test site. Only very little streams and few small ponds are apparent. The situation in the test site Steinbeißen is similar. The village Steinbeißen itself is located in the Vils valley and is situated directly next to the river Vils. The riverbed is bordered by some ponds and back water pools. Several little streams, coming from the south, are flowing towards the Vils main stream. During an extreme rain event on the 5th of July 2009, with more than 87 mm of precipitation falling during a thunderstorm, those tributaries left their beds and a relatively large surrounding area was seriously flooded. Figure 10.04 shows some of the damage caused by the flooding, still visible during the ground measurement campaign at the end of July. During the field campaigns the soils were still rather wet, increasingly towards the valley bottom where the river Vils has its bed. Standing water could be observed on the fields.

Figure 10.04: Soil erosion (left) and standing water in the fields (right) as result of the extreme rainfall event on July 5th 2009. The photographs were taken on the 27th of July 2009 during the ground truth campaign.

10.1.4 Soils

The soils of both test sites represent rich and fertile soil types as they are typical for regions dominated by periglacial pedogenetic conditions. Soils around Neusling are quite homogenously distributed loess loams with very high percentages of silt (Figs. 10.06 and 10.07).

The soils around Steinbeißen contain more sand (Fig. 10.05) and are a bit more heterogeneously distributed. In both cases, the upper soil layers are rich in humus, while Ap horizons are dominating the stratification, since the area is intensively cultivated.

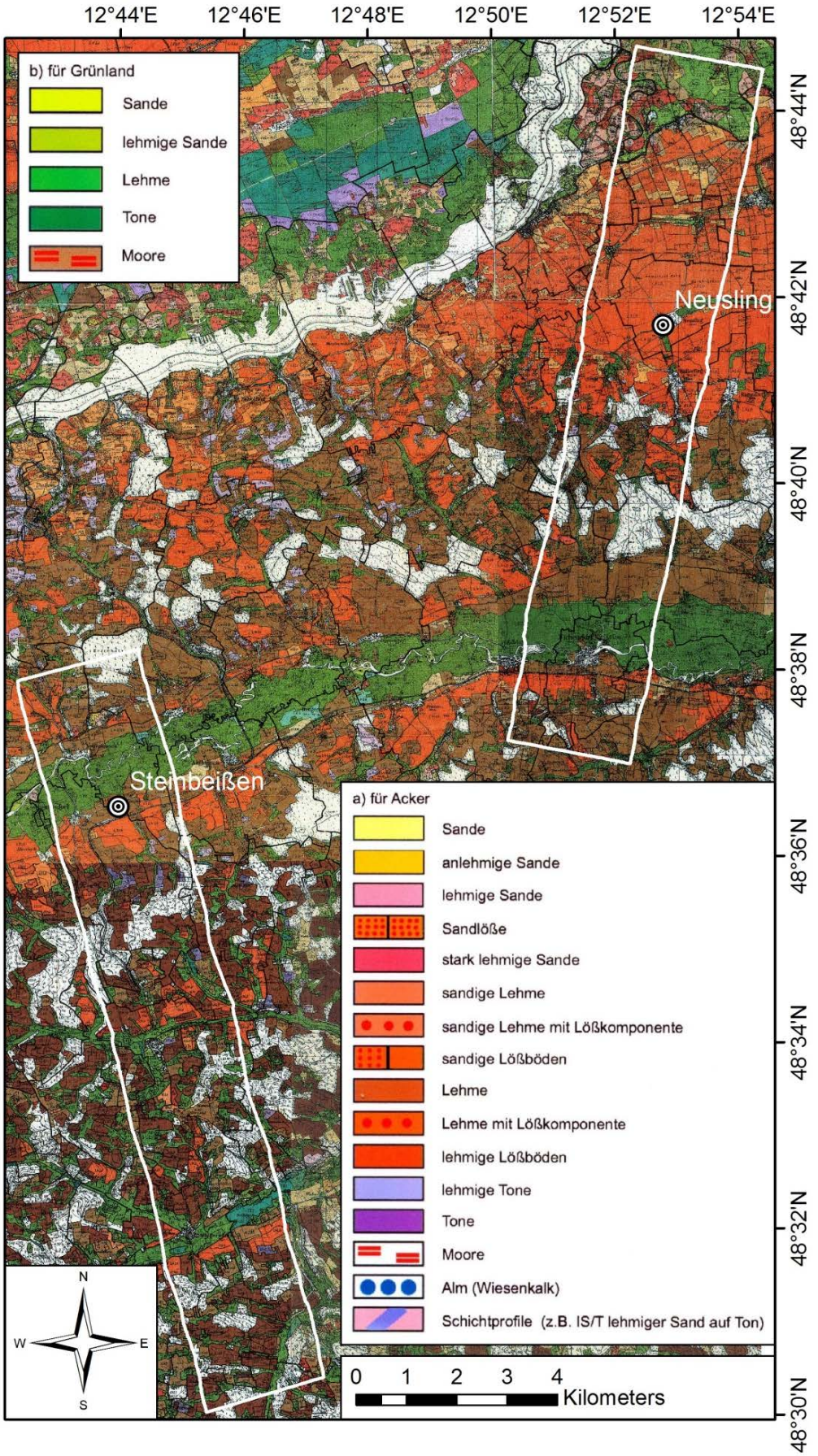


Figure 10.05: Soil evaluation map, kindly provided by the Bavarian State Office of Geology (adapted). The white lines indicate the spatial extent of the two HyMap acquisitions over Neusling (north) and Steinbeißen (south).

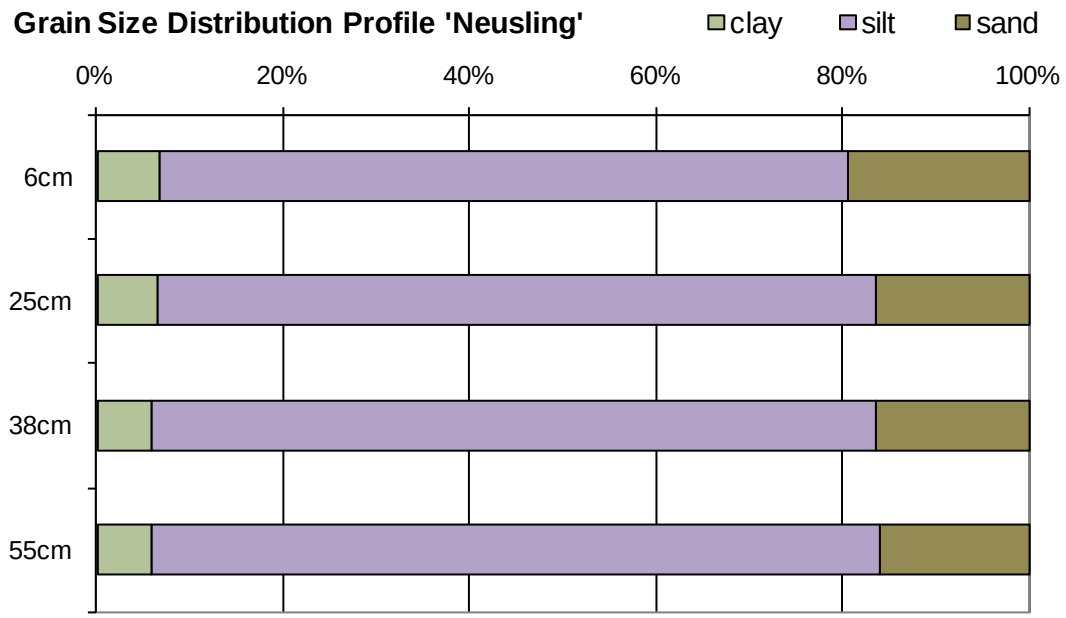


Figure 10.06: Profile of soil grain size distribution within the uppermost 55 cm of an exemplary soil column near Neusling.

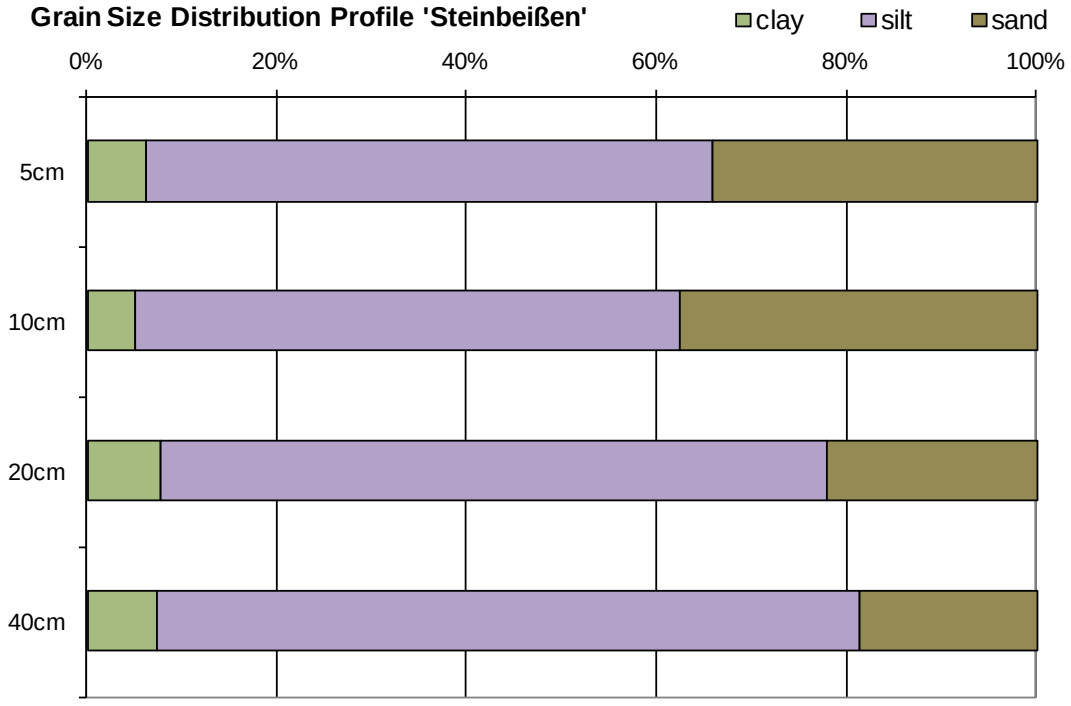


Figure 10.07: Profile of soil grain size distribution within the uppermost 40 cm of an exemplary soil column near Steinbeißen.

10.1.5 Vegetation

The main parts of the test sites are dominated by intensive agricultural cultivation as the soils are very fertile. Only the hilly areas, where the higher relief energy restrains the application of large machinery, are forested providing biotopes for natural flora and fauna.

The most common crops cultivated in the area are cereals, consisting mostly of winter wheat and maize, followed by sugar beet and grassland. Also potato and other field vegetables like cucumbers and beans are dominant crops (see Figs. 10.08 and 10.09 as well as Table 10.02).

Both test sites cover nearly the same area with 35.32 km² and 36.91 km², respectively (see Table 10.02). However, while sugar beet is well represented in the Neusling area, it is rarely found in the Steinbeißen area.

Table 10.02: Distribution of aggregated land cover categories as observed for both test sites during the ground measurement campaign in July 2009.

	Neusling		Steinbeißen	
Land Cover	**km²**	**%**	**km²**	**%**
Cereals	10.93	30.94%	9.45	25.61%
Maize	5.27	14.91%	8.01	21.72%
Sugar Beet	5.15	14.57%	0.87	2.35%
Forest	3.65	10.33%	7.88	21.36%
Sealed	3.51	9.95%	4.43	12.01%
Grassland	1.84	5.21%	4.33	11.74%
Cucumber	1.54	4.37%	0.35	0.94%
Other Arable	1.53	4.33%	1.28	3.48%
Potatos	1.22	3.45%	0.25	0.69%
Other	0.61	1.73%	0.04	0.11%
Water	0.07	0.21%	0.00	0.00%
Total	**35.32**	**100.00%**	**36.91**	**100.00%**

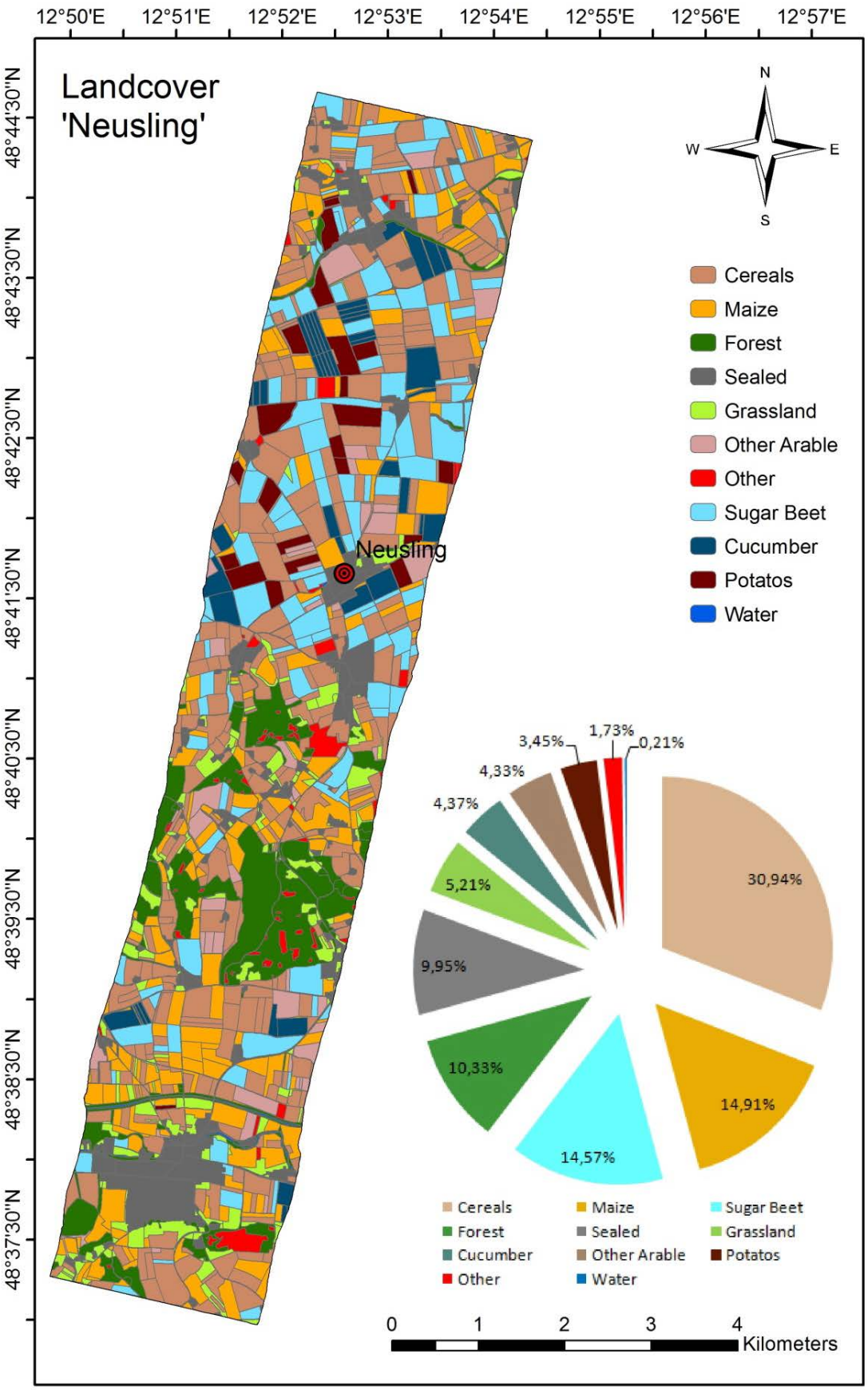


Figure 10.08: Aggregated major land cover types and their corresponding area percentages as mapped for the test site 'Neusling' during the ground truth campaign in July 2009 (category 'cereals' includes mainly winter wheat).

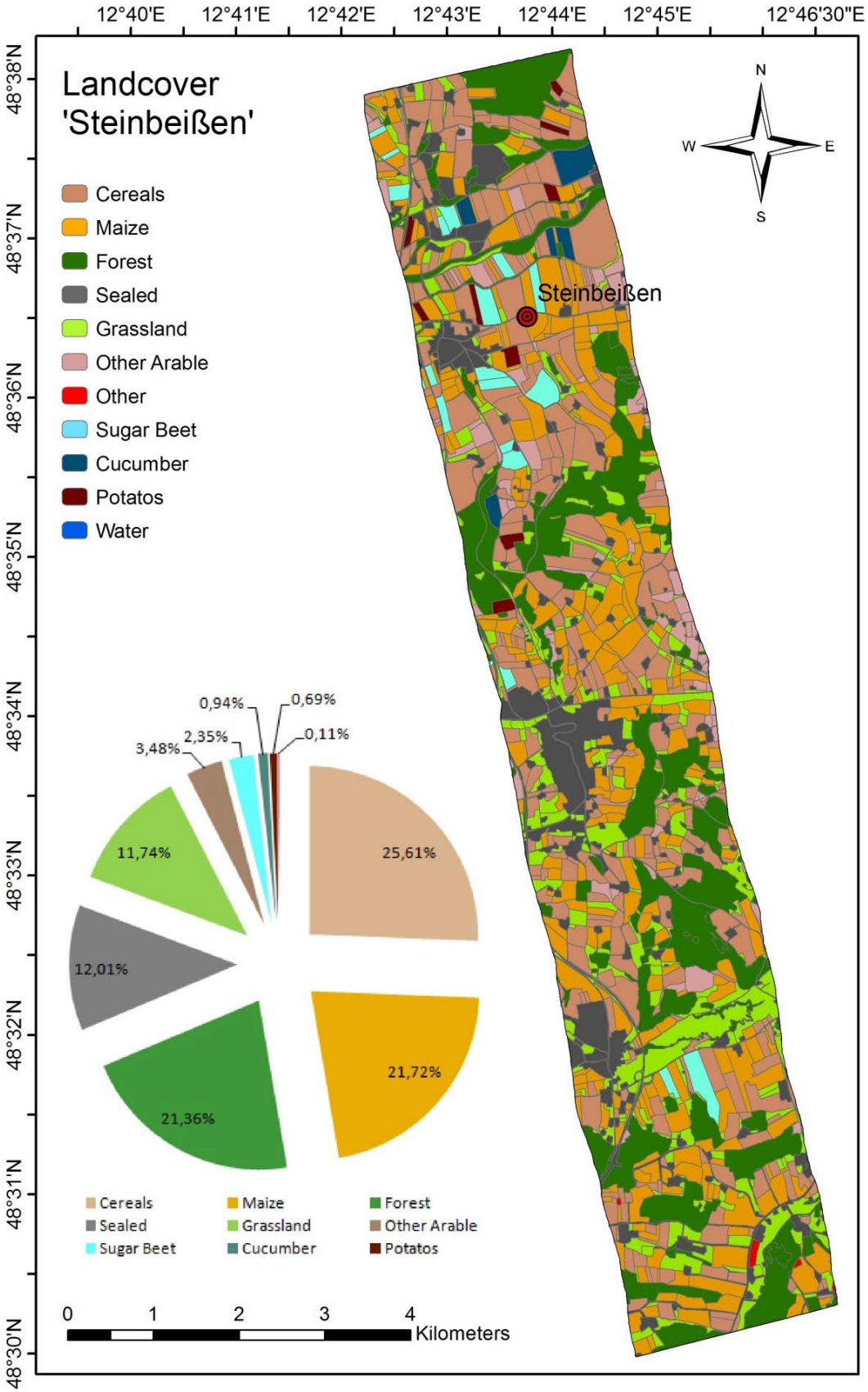


Figure 10.09: Aggregated major land cover types and their corresponding area percentages as mapped for the test site 'Steinbeißen' during the ground measurement campaign in July 2009.

10.1.6 Socio-Economic Aspects

Due to the high fertility of the soils in the area, the landscape and living environment of the region is dominated by technically highly advanced agriculture. The region is one of the most abundantly technically equipped agricultural production areas of Europe, the density of agricultural machinery being exceptionally high. Large agglomerations are represented by the city of Dingolfing (approx. 18.500 inhabitants) and 'Landau an der Isar' (approx. 13.000 inhabitants). The zone of attraction of both cities is defining the rural district Dingolfing-Landau as part of the administrative district of Lower Bavaria (Table 10.03).

Table 10.03: Administrative affiliation of the test area.

Country:	Germany
Federal State:	Bavaria
Region:	Lower Bavaria
Rural district:	Dingolfing-Landau

10.2 Ground Control points used for Geometric Post-Processing

Flightstrip 1 (Neusling)

Source		Target	
UTM Easting	**UTM Northing**	**UTM Easting**	**UTM Northing**
343868.02	5400016.04	343878.63	5400005.35
345252.08	5400467.87	345253.40	5400477.04
344091.93	5400928.21	344102.57	5400916.81
344479.79	5399044.03	344482.25	5399046.24
344655.93	5397708.00	344657.85	5397715.42
345767.90	5399367.89	345764.82	5399385.93
343096.08	5398615.92	343107.31	5398598.52
342783.79	5397211.78	342795.65	5397195.94
344531.87	5397068.03	344534.03	5397076.15
344067.98	5395732.05	344070.42	5395737.40
342899.97	5395068.03	342911.61	5395061.91
344176.05	5394464.06	344178.39	5394474.61
342564.08	5394124.02	342575.89	5394114.78
343991.89	5392784.03	343990.56	5392799.81
342095.98	5392788.01	342108.37	5392776.04
342096.15	5392787.95	342109.57	5392775.49
343887.90	5391376.18	343886.74	5391393.31
342527.85	5391776.09	342535.83	5391772.96
341344.04	5390995.89	341360.94	5390981.60
343619.89	5390596.02	343618.84	5390613.95
342463.80	5389880.05	342471.90	5389882.67
341051.93	5389855.83	341069.37	5389838.62
343351.89	5388756.05	343351.09	5388775.81
342051.90	5389160.04	342060.35	5389159.26
342023.98	5390000.02	342036.32	5389998.59
341051.90	5388812.01	341069.18	5388799.69
342267.96	5388743.95	342276.10	5388747.72
341231.98	5387979.94	341245.04	5387972.56
341939.91	5387920.06	341948.43	5387924.55
342956.02	5387248.10	342955.44	5387265.14
340519.85	5387620.03	340537.73	5387604.77
345928.02	5400652.11	345924.78	5400668.84
343332.13	5397716.15	343343.23	5397707.48
342631.98	5396143.98	342643.80	5396128.99
343903.92	5396576.10	343910.60	5396576.73
345443.97	5398520.10	345441.28	5398534.69

Flightstrip 2 (Steinbeißen)

Source		Target	
UTM Easting	**UTM Northing**	**UTM Easting**	**UTM Northing**
331207.99	5389131.96	331215.29	5389113.65
333004.06	5388496.11	333007.97	5388510.70
331503.96	5387107.98	331512.72	5387087.78
333844.02	5387119.95	333844.05	5387144.05
331543.91	5386048.01	331552.94	5386022.51
334087.98	5385555.92	334089.29	5385576.27
331900.04	5384323.96	331910.69	5384298.14
334159.93	5384195.95	334161.77	5384213.85
332339.97	5382960.10	332348.79	5382935.46
334747.97	5382812.12	334748.45	5382835.05
332603.90	5381379.93	332613.95	5381355.79
335295.85	5379956.06	335295.14	5379977.04
333180.05	5378475.89	333188.88	5378449.62
335752.07	5377627.98	335753.34	5377645.66
333803.93	5375991.96	333811.85	5375965.49
336267.93	5375071.99	336267.86	5375089.26
333995.87	5374543.88	334004.83	5374514.48
335300.08	5375159.89	335303.15	5375157.53
334879.99	5376568.04	334885.19	5376564.48
334111.84	5377768.00	334117.41	5377754.23
333723.96	5379995.99	333731.58	5379985.11
333883.91	5381192.09	333888.23	5381190.97
333339.93	5382472.02	333345.56	5382465.28
333135.98	5384708.00	333140.55	5384708.10
332379.86	5386223.99	332384.90	5386215.48
332223.95	5388483.96	332228.19	5388482.57
333076.08	5389327.86	333076.32	5389346.72
331448.00	5387855.69	331456.59	5387835.38
332527.99	5385407.94	332533.62	5385399.57
333723.90	5383107.96	333727.49	5383112.35
333080.09	5379895.92	333088.24	5379872.67
335063.95	5378247.91	335065.98	5378256.54
335967.77	5375984.00	335970.36	5375997.69
334759.91	5378719.88	334764.54	5378722.98
332691.91	5383584.01	332698.42	5383570.75

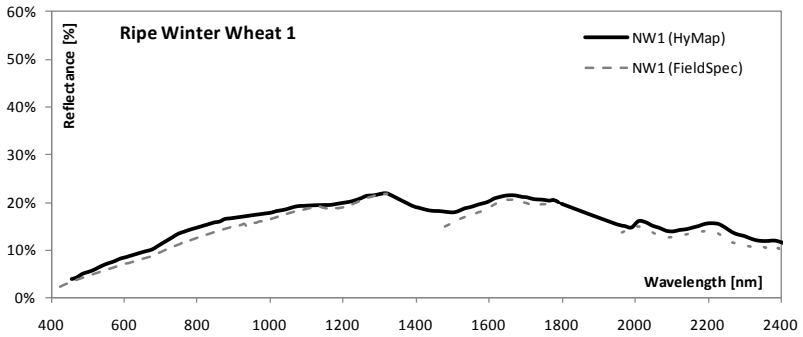
10.3 Spectral Bands of the HyMap Instrument

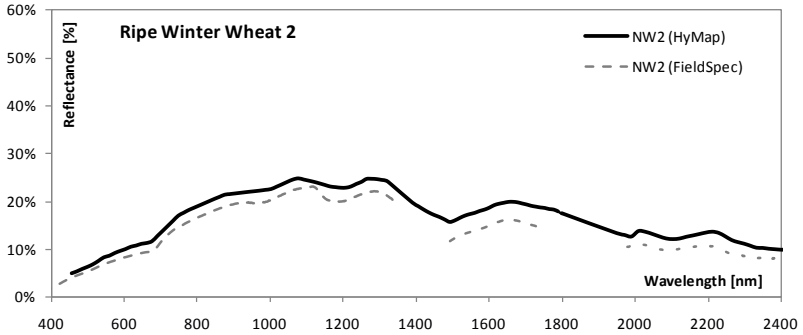
Band	Wavelength [nm]	FWHM Bandwidth [nm]	Spectral Domain	Spectrometer
1	455.4	13.2	VIS-BLUE	VIS
2	469.4	15.4		
3	484.3	14.8		
4	499.1	14.7		
5	513.8	15.5	VIS-GREEN	
6	528.8	16.0		
7	543.6	15.3		
8	558.4	15.2		
9	573.1	15.2		
10	588.1	15.2		
11	602.9	15.2	VIS-RED	
12	617.6	15.1		
13	632.0	15.2		
14	646.5	15.3		
15	660.9	15.4		
16	675.5	15.6		
17	690.0	15.5		
18	704.5	15.7	NIR	
19	718.9	15.5		
20	733.2	15.6		
21	747.6	15.6		
22	761.8	15.7		
23	775.9	15.6		
24	790.1	15.7		
25	804.6	16.2		
26	818.8	15.9		
27	832.9	16.1		
28	847.1	16.3		
29	861.1	16.2		
30	874.7	16.1		
31	887.8	15.5		
32	893.0	18.4		
33	908.5	17.2	SWIR	NIR
34	923.9	17.3		
35	939.4	17.4		
36	955.2	17.5		
37	970.4	17.0		
38	985.8	17.1		
39	1001.4	17.2		
40	1016.6	16.7		
41	1031.8	16.9		

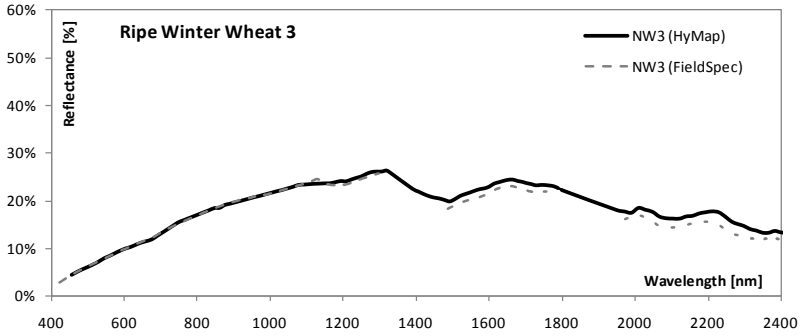
Band	Wavelength [nm]	FWHM Bandwidth [nm]	Spectral Domain	Spectrometer
42	1046.9	16.8		
43	1062.0	16.5		
44	1076.6	16.4		
45	1091.3	16.7		
46	1106.2	16.6		
47	1120.8	16.6		
48	1135.3	16.6		
49	1149.7	16.3		
50	1164.1	16.3		
51	1178.6	16.3		
52	1192.8	16.2		
53	1206.9	16.2		
54	1221.0	16.2		
55	1235.1	16.0		
56	1249.2	16.4		
57	1263.1	16.0		
58	1277.0	16.2		
59	1290.7	16.0		
60	1304.3	16.2		
61	1318.3	16.4		
62	1330.1	16.1		
63	1388.8	13.3		
64	1404.6	16.4		
65	1419.4	15.7		SWIR-1
66	1433.8	15.7		
67	1448.3	15.5		
68	1462.6	15.5		
69	1477.1	15.4		
70	1491.1	15.2		
71	1505.0	15.2		
72	1518.8	15.4		
73	1532.6	15.4		
74	1546.3	15.0		
75	1559.8	15.0		
76	1573.2	14.9		
77	1586.4	14.9		
78	1599.5	14.7		
79	1612.7	14.8		
80	1625.9	14.7		
81	1638.9	14.5		
82	1651.7	14.4		
83	1664.4	14.2		
84	1677.1	14.1		

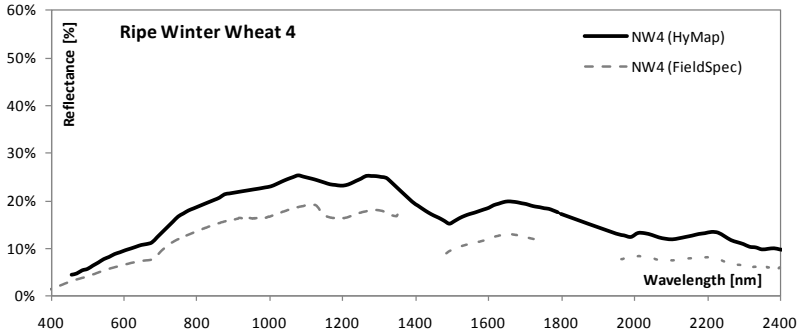
Band	Wavelength [nm]	FWHM Bandwidth [nm]	Spectral Domain	Spectrometer
85	1689.6	14.1		
86	1702.1	13.9		
87	1714.6	13.8		
88	1726.9	13.7		
89	1739.3	13.4		
90	1751.5	13.4		
91	1763.6	13.5		
92	1775.6	13.2		
93	1787.6	13.0		
94	1798.1	13.3	MIR-1	
95	1948.5	20.6		
96	1969.7	21.8		
97	1989.0	21.9		
98	2008.3	21.2		
99	2027.5	21.3		
100	2046.7	21.2		
101	2065.5	20.8		
102	2084.1	20.5		
103	2102.5	20.0		
104	2120.9	20.0		
105	2139.0	19.7		
106	2157.0	19.4		
107	2174.7	19.1		
108	2191.7	19.0	MIR-2	
109	2210.3	19.8		
110	2228.1	18.6		SWIR-2
111	2245.6	19.1		
112	2263.4	18.2		
113	2280.4	18.2		
114	2297.4	18.1		
115	2314.4	18.0		
116	2331.4	17.9		
117	2348.3	17.8		
118	2365.0	17.9		
119	2381.5	17.3		
120	2397.7	17.3	MIR-3	
121	2414.1	17.5		
122	2430.3	17.4		
123	2446.5	17.2		
124	2462.4	17.0		
125	2478.0	16.3		

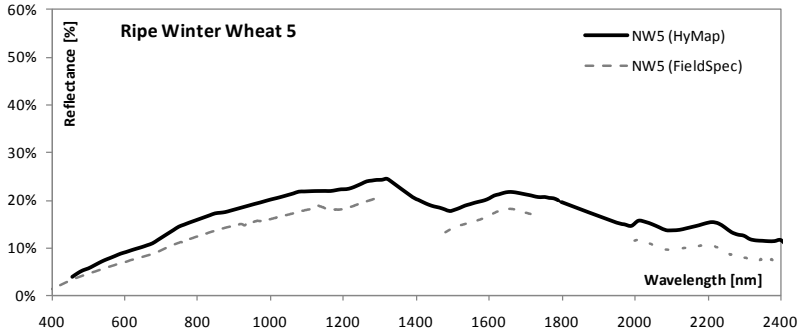
10.4 HyMap vs. FieldSpec – Neusling Winter Wheat



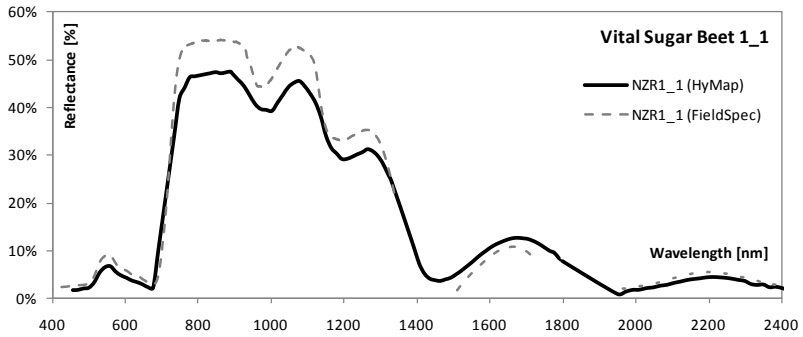


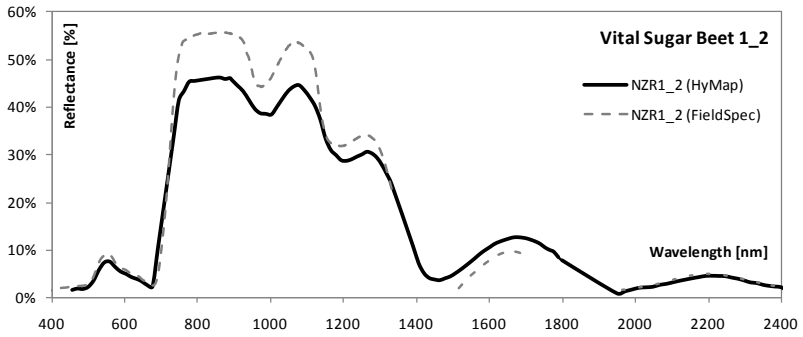


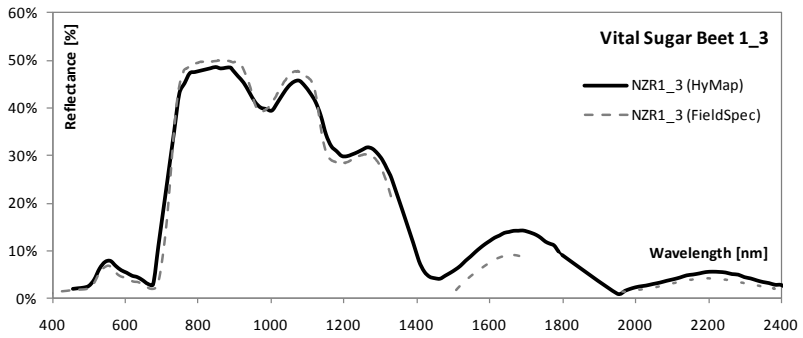


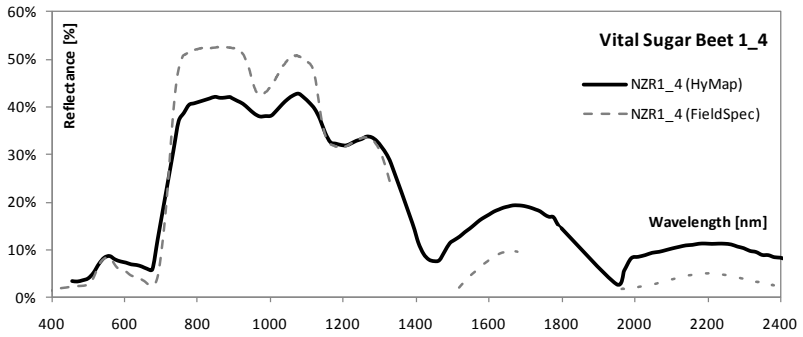


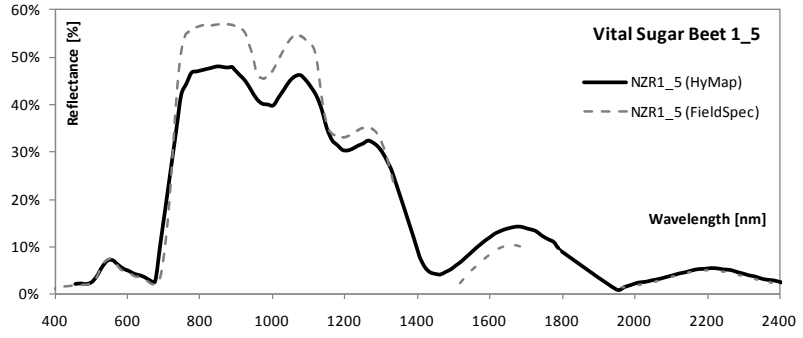
10.5 HyMap vs. FieldSpec – Neusling Sugar Beet

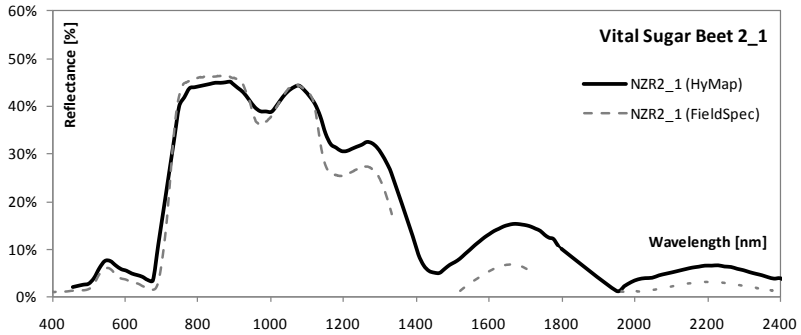


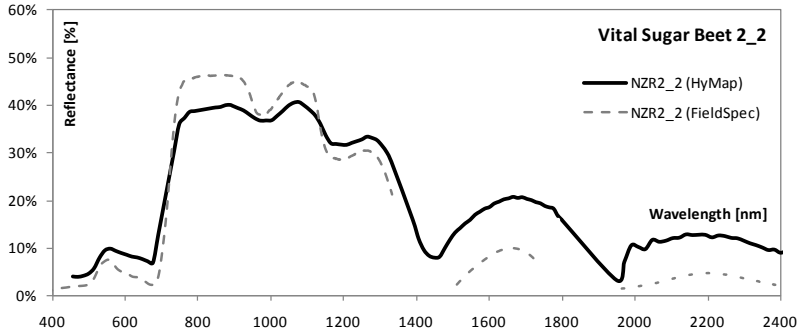









Vital Sugar Beet 2_1
NZR2_1 (HyMap)
NZR2_1 (FieldSpec)
Reflectance [%]
Wavelength [nm]
60%
50%
40%
30%
20%
10%
0%
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400


Vital Sugar Beet 2_2
NZR2_2 (HyMap)
NZR2_2 (FieldSpec)
Reflectance [%]
Wavelength [nm]
60%
50%
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20%
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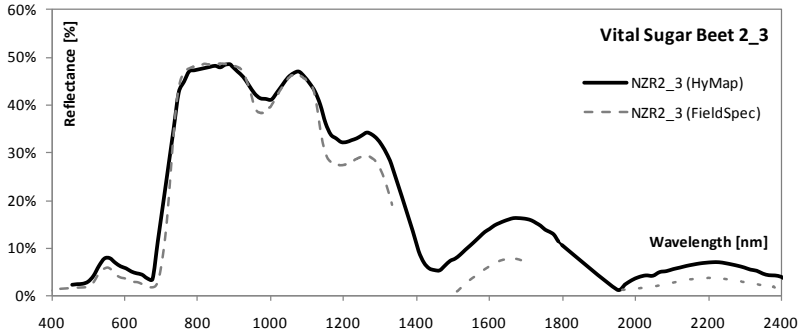
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NZR2_3 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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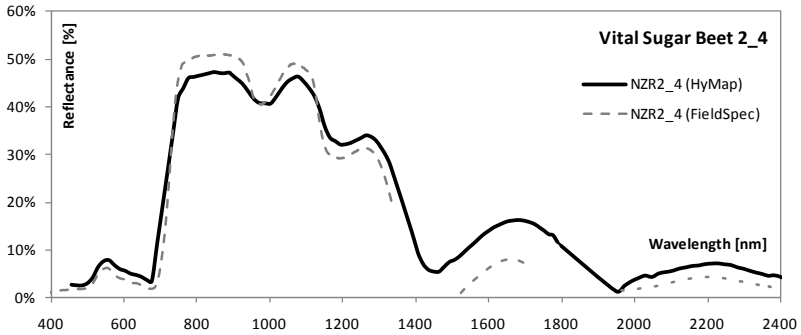
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NZR2_4 (FieldSpec)
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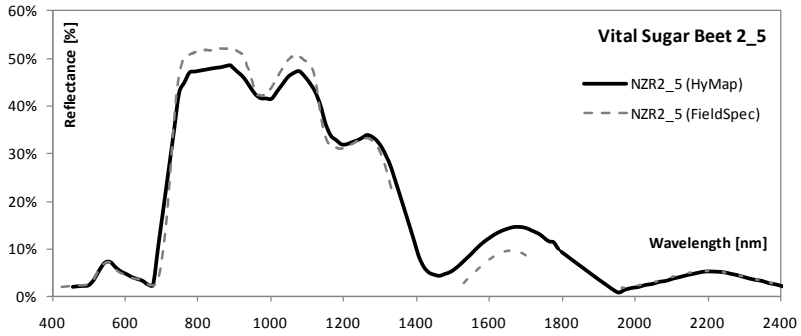
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NZR2_5 (FieldSpec)
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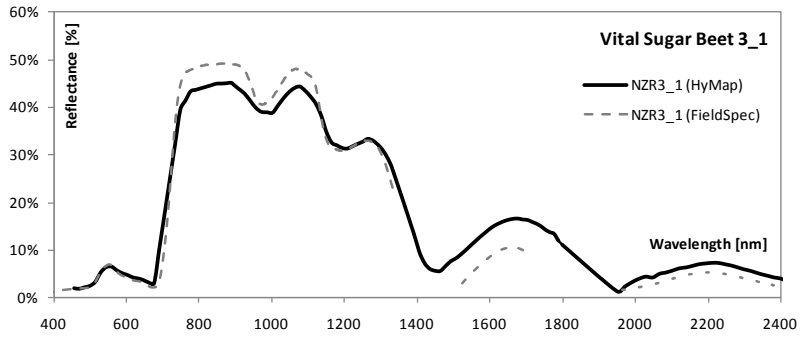
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NZR3_1 (FieldSpec)
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Wavelength [nm]
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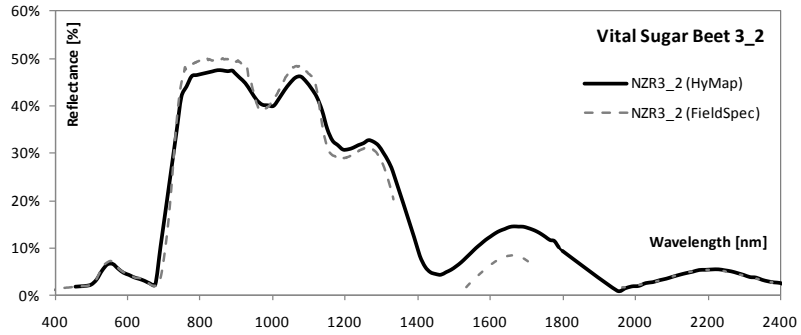
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NZR3_2 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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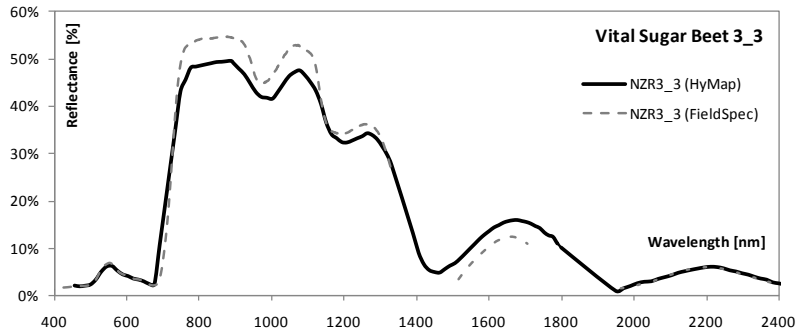
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NZR3_3 (HyMap)
NZR3_3 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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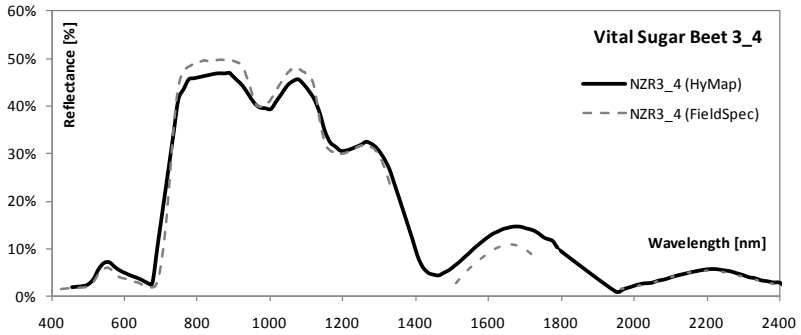
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NZR3_4 (HyMap)
NZR3_4 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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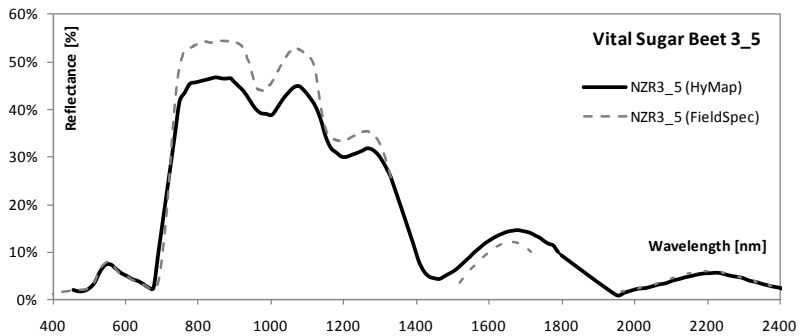
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NZR3_5 (HyMap)
NZR3_5 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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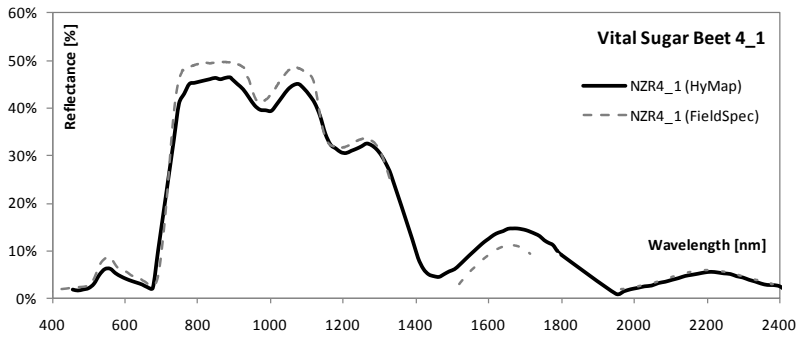
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NZR4_1 (HyMap)
NZR4_1 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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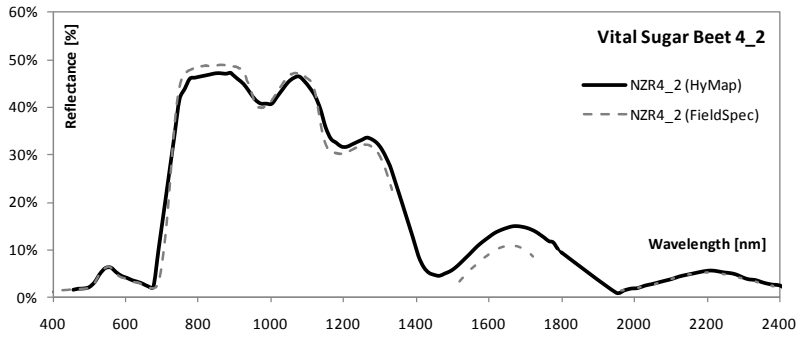
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NZR4_2 (HyMap)
NZR4_2 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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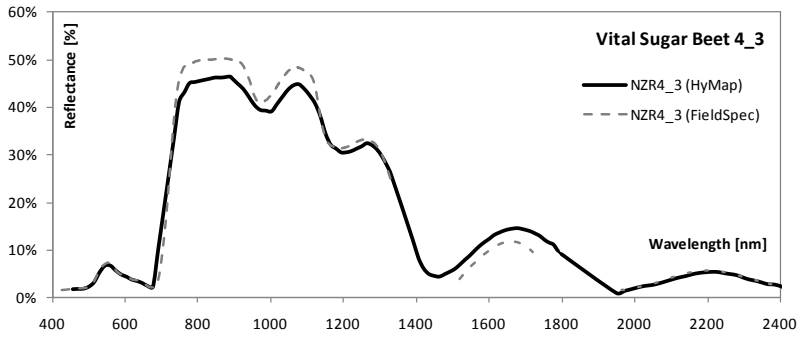
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NZR4_3 (HyMap)
NZR4_3 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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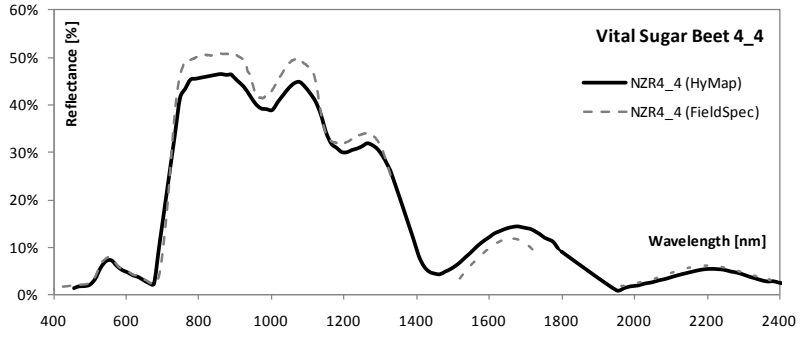
Vital Sugar Beet 4_4
NZR4_4 (HyMap)
NZR4_4 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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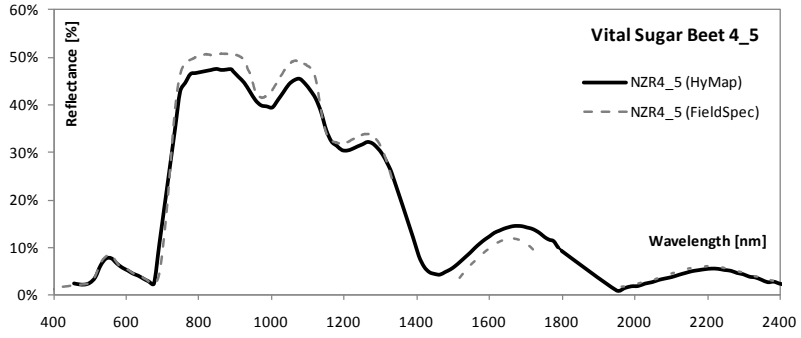
Vital Sugar Beet 4_5
NZR4_5 (HyMap)
NZR4_5 (FieldSpec)
Reflectance [%]
Wavelength [nm]
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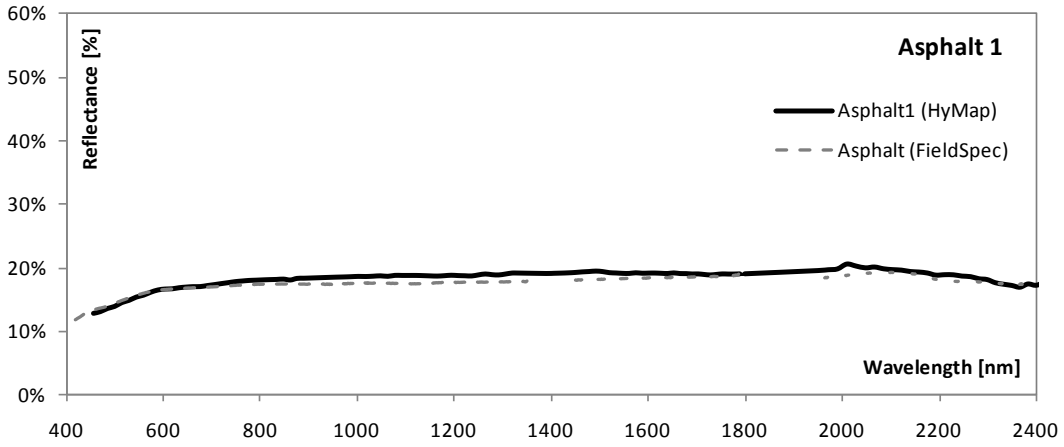
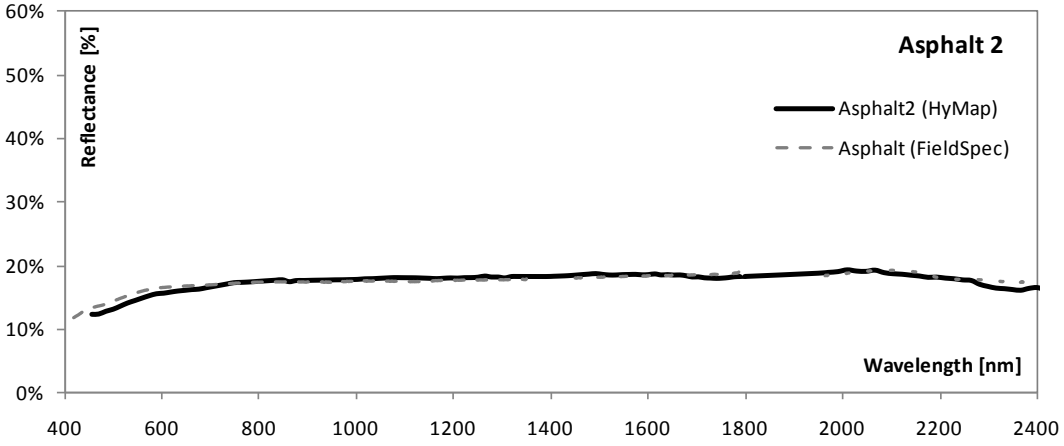
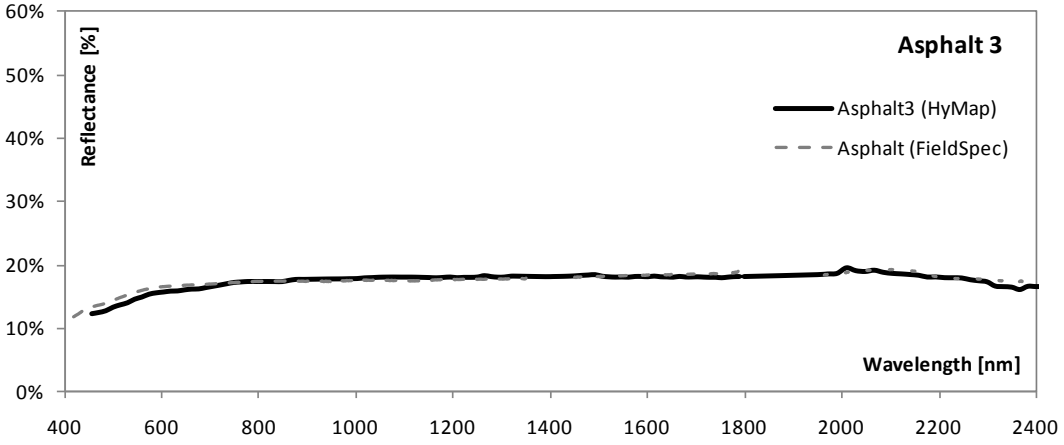
10.6 HyMap vs. FieldSpec – Neusling Asphalt







10.7 IGGF-Code for land cover classification

ID	Landuse	Species	Type
100	Arable Land		Agriculture
101	Winter Wheat	*Triticum aestivum*	
102	Summer Wheat	*Triticum aestivum*	
103	Rye	*Secale cereale*	
104	Winter Barley	*Hordeum vulgare*	
105	Summer Barley	*Hordeum vulgare*	
106	Oat	*Avena sativa*	
107	Triticale	*Triticale*	
108	Corn Maize	*Zea mays*	
109	Maize Silage	*Zea mays*	
110	Wild Emmer	*Triticum dicoccum*	
111	Sudan Grass	*Sorghum sudanese*	
201	Field Bean	*Vicia faba*	
202	Winter Rape	*Brassica napus*	
206	Potatoes	*Solanum tuberosum*	
300	Arable Land (unworked)		
301	Fallow		
302	Legumes	*Phacelia*	
303	Sunflowers	*Helianthus annuus*	
304	Sugar Beet	*Beta vulgaris*	
305	Field Vegetables	*Brassica oleracea*	
306	Spelt	*Triticum spelta*	
307	Cucumber	*Cucumis sativus*	
308	Harvested Wheat Field (harrowed)		
309	Harvested Wheat Field (unworked)		
310	Bare Soil (harrowed)		
311	Onions	*Allium cepa*	
320	Other Gardening		Gardening
321	Cut Flowers		
322	Strawberries	*Fragaria*	
323	Raspberries	*Rubus idaeus*	
324	Sunflowers	*Helianthus annuus*	
400	Grassland undiff.		Grassland
401	Meadow		
402	Cut Pasture		
403	Pasture		
406	Airfield		
407	Paddock (Golf course)		
408	Soccer Ground		
409	Reed	*Poaceae*	

ID	Landuse	Species	Type
500	Forest undiff.		Forest
501	Deciduous Forest	*Mainly Fagus sylvatica*	
502	Coniferous Forest	*Mainly Picea abies*	
503	Mixed Forest		
504	Low-Density Tree Population		
505	Clear Cutting / Windbreak		
506	Shrubbery / Floodplain Vegetation		
507	Afforestation / Young Forest Protection Area		
601	Moor (with tree cover)		
602	Orchard		
701	Standing Water Body		Water
702	Flowing Water Body		
800	Gravel Pit		
900	Sealed Area (undiff.)		Sealed
910	Settlement Area (undiff.)		
911	High-Density Settlement Area		
912	Low-Density Settlement Area		
913	Single Farmstead		
920	Trafficway (undiff.)		
921	Highway		
922	Main Road		
923	Side Road		
924	Dirt Track		
925	Railway		
926	Cobble Stone Pavement		
950	Grassland Area (with dump use)		Other
1000	Other or unknown land cover		

10.8 Example of a Data Form used for the collection of field data

Standort:		Eine eindeutige Bezeichnung des Messstandorts, z.B.: "Supertestweizen 1"
Datum:		Das aktuelle Datum
Uhrzeit:		Die Uhrzeit der Beobachtung
Rechtswert:		Werte aus dem GPS (Gauß-Krüger!)
Hochwert:		Werte aus dem GPS (Gauß-Krüger!)
Höhe:		Werte aus dem GPS
Landnutzung:		Bestimmungsbücher!
Phänologie [BBCH]:		Das Wachstumsstadium wird entsprechend des BBCH-Codes bestimmt
Beobachtung:		z.B.: Überschwemmungsflächen, sichtbare Schäden, Auffälligkeiten
Wetter:		Bewölkungsgrad, Wind, evtl. Temperatur
Wuchshöhe:		Die Wuchshöhe wird mit dem Meterstab bestimmt.
Evtl. Reihenabstand:		Es wird der Abstand der Saatreihen gemessen.
Pflanzendichte [Pfl/2m]:		Es wird die Anzahl der Pflanzen entlang einer Saatreihe auf 2m Länge gezählt.
Gewicht der Schale [g]		Das Gewicht der Probenschale alleine vor dem Wiegen der Feuchtmasse
Feuchtgewicht [g]		Es werden drei Pflanzen entlang einer Saatreihe direkt über dem Boden abgeschnitten. Bei Grünland wird 1/4 m² abgemäht.
Gewicht der Schale [g]		Das Gewicht der Probenschale alleine vor dem Wiegen der Trockenmasse
Trockengewicht [g]		Nach Trocknung der Proben im Labor
LAI / SEL:		Abgelesenes Ergebnis des LAI-Meters
Bodenfeuchte [%]:		Abgelesenes Ergebnis der FDR-Sonde
Horizontalphoto:		Name oder Nummer der Digitalphotos
Spektrometer:		Base Name der Spektrometermessung

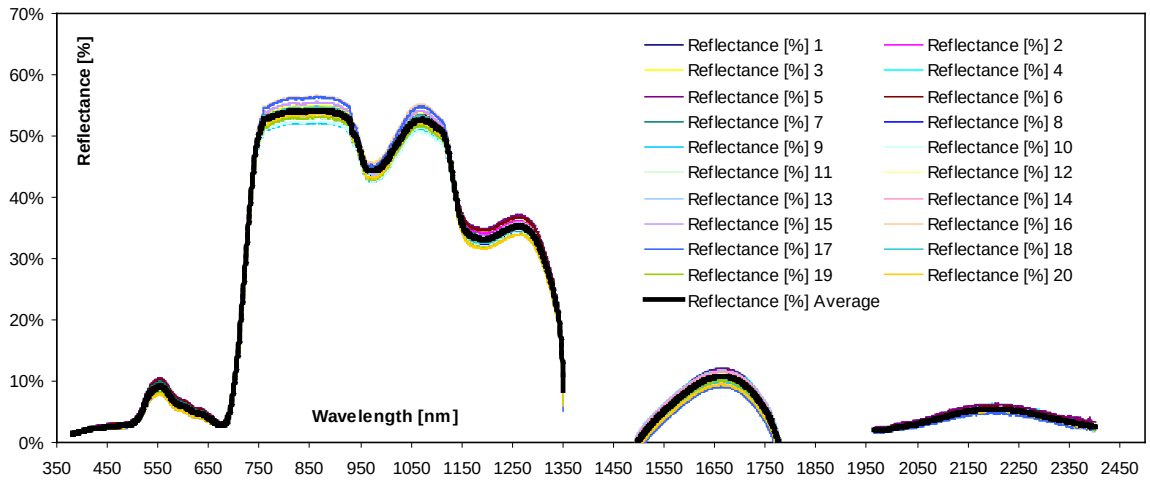
10.9 Data sheets of the 'Neusling' test area

Testsite Neusling – Sample Point NZR1/1	
Date:	2009-07-27
Time [CEST]:	08:45
Easting [GK]:	^{45}64583
Northing [GK]:	^{53}95271
Height above Sea Level [m]:	347
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Very wet soil
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	54
Row distance [cm]:	40
Plant density [Plt. m^{-2}]:	12.5
Soil Moisture [%]:	30.3
Wet aboveground biomass [g m^{-2}]	10128.75
Dry aboveground biomass [g m^{-2}]	904.50
Biomass water content [g m^{-2}]	9224.25
Biomass moisture [%]	91.07
Leaf Area Index	5.38
LAI std. Dev.	0.21

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



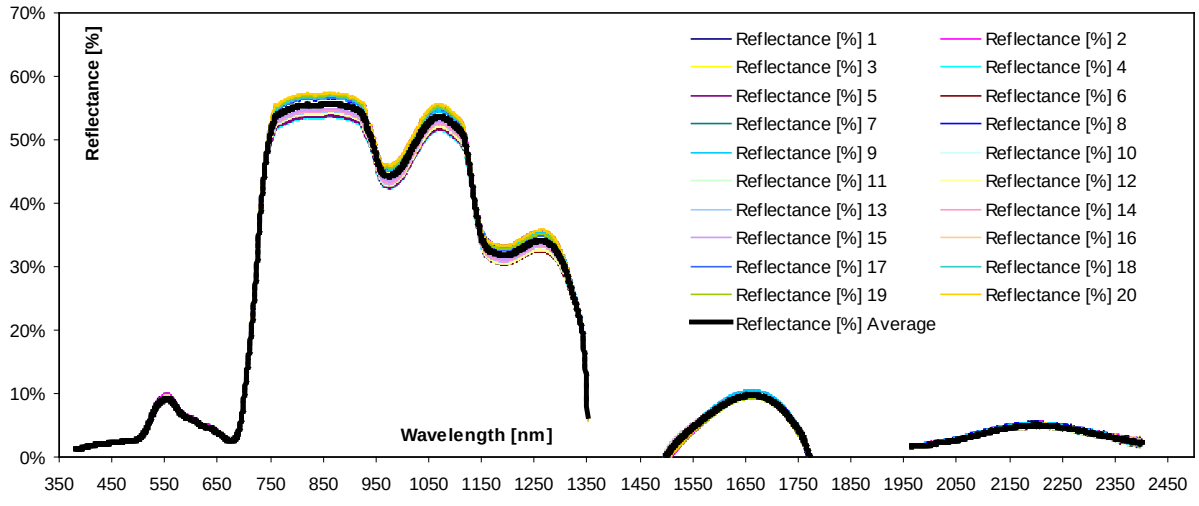
Testsite Neusling – Sample Point NZR1/2

Date:	2009-07-27
Time [CEST]:	09:07
Easting [GK]:	^{45}64637
Northing [GK]:	^{53}95046
Height above Sea Level [m]:	350
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Slightly yellowish leaves
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	51.60
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	27.43
Wet aboveground biomass [g m^{-2}]	5240.67
Dry aboveground biomass [g m^{-2}]	480.00
Biomass water content [g m^{-2}]	4760.67
Biomass moisture [%]	90.84
Leaf Area Index	5.20
LAI std. Dev.	0.02

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



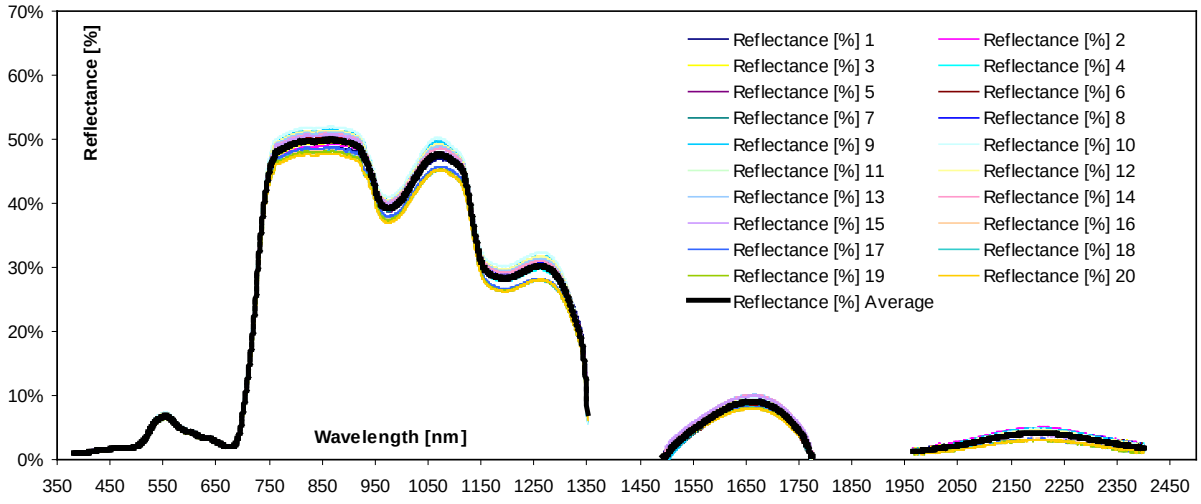
Testsite Neusling – Sample Point NZR1/3

Date:	2009-07-27
Time [CEST]:	09:25
Easting [GK]:	^{45}64285
Northing [GK]:	^{53}94914
Height above Sea Level [m]:	354
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Slopes to the east
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	57
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	10
Soil Moisture [%]:	28.63
Wet aboveground biomass [g m^{-2}]	7310.00
Dry aboveground biomass [g m^{-2}]	668.89
Biomass water content [g m^{-2}]	6641.11
Biomass moisture [%]	90.85
Leaf Area Index	4.84
LAI std. Dev.	0.02

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

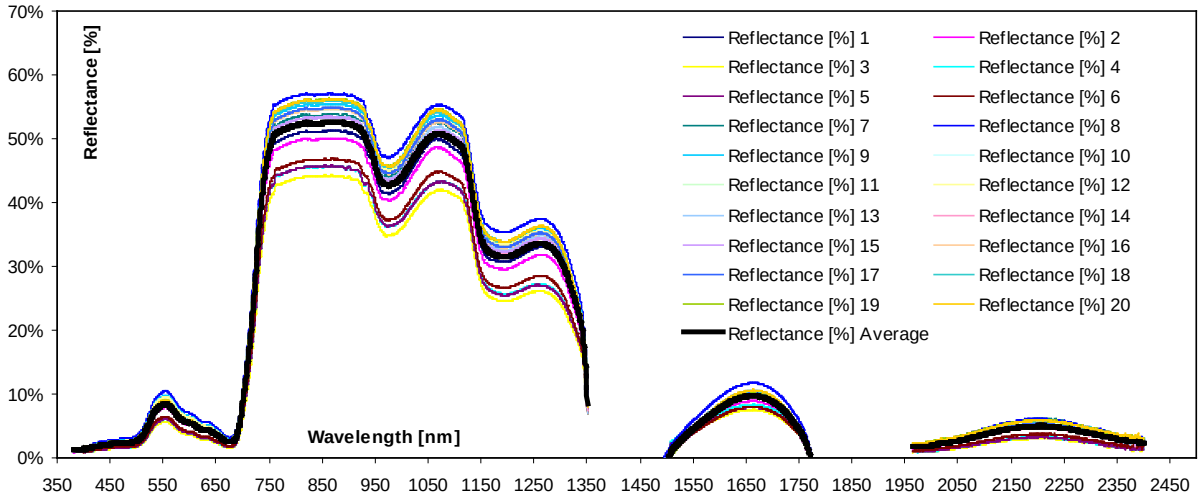


Testsite Neusling – Sample Point NZR1/4	
Date:	2009-07-27
Time [CEST]:	09:37
Easting [GK]:	^{45}64242
Northing [GK]:	^{53}95066
Height above Sea Level [m]:	350
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Very wet
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	60
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	28.4
Wet aboveground biomass [g m^{-2}]	11485.11
Dry aboveground biomass [g m^{-2}]	1164.44
Biomass water content [g m^{-2}]	10320.67
Biomass moisture [%]	89.86
Leaf Area Index	5.74
LAI std. Dev.	0.06

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

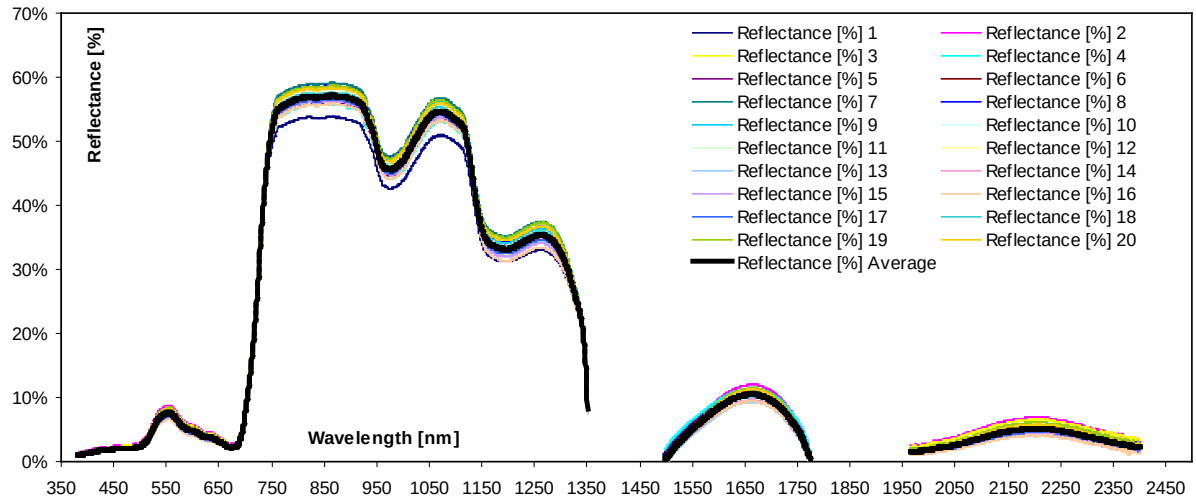


Testsite Neusling – Sample Point NZR1/5	
Date:	2009-07-27
Time [CEST]:	09:52
Easting [GK]:	^{45}64388
Northing [GK]:	^{53}95065
Height above Sea Level [m]:	345
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Partly water clogged
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	60.40
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	12.22
Soil Moisture [%]:	28.4
Wet aboveground biomass [g m^{-2}]	11485.11
Dry aboveground biomass [g m^{-2}]	1164.44
Biomass water content [g m^{-2}]	10320.67
Biomass moisture [%]	89.86
Leaf Area Index	5.40
LAI std. Dev.	0.01

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

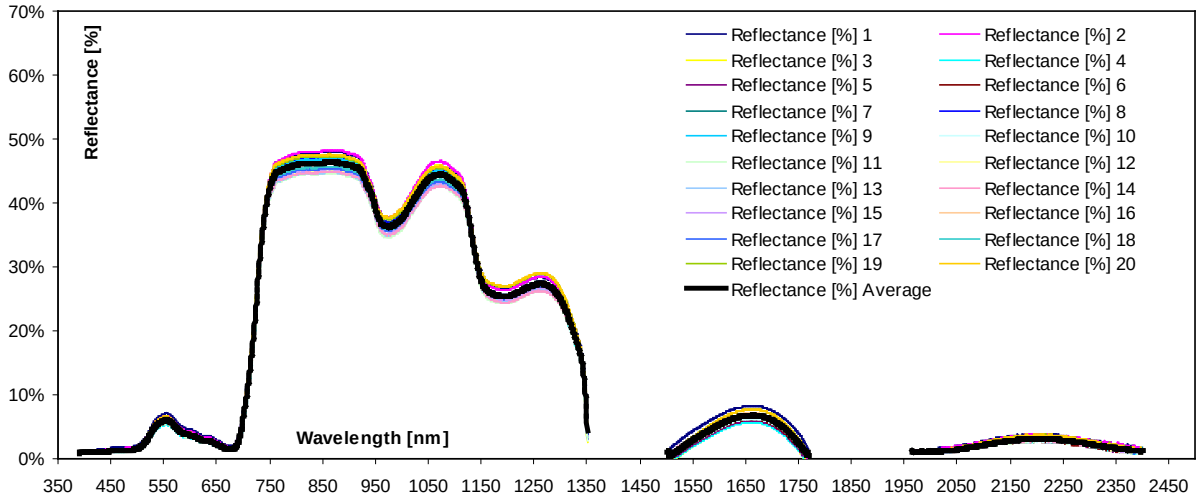


Testsite Neusling – Sample Point NZR2/1	
Date:	2009-07-27
Time [CEST]:	10:01
Easting [GK]:	^{45}64351
Northing [GK]:	^{53}95201
Height above Sea Level [m]:	345
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Bleached leaves
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	50
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.67
Soil Moisture [%]:	28.53
Wet aboveground biomass [g m^{-2}]	8124.67
Dry aboveground biomass [g m^{-2}]	803.56
Biomass water content [g m^{-2}]	7321.11
Biomass moisture [%]	90.11
Leaf Area Index	4.68
LAI std. Dev.	0.38

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

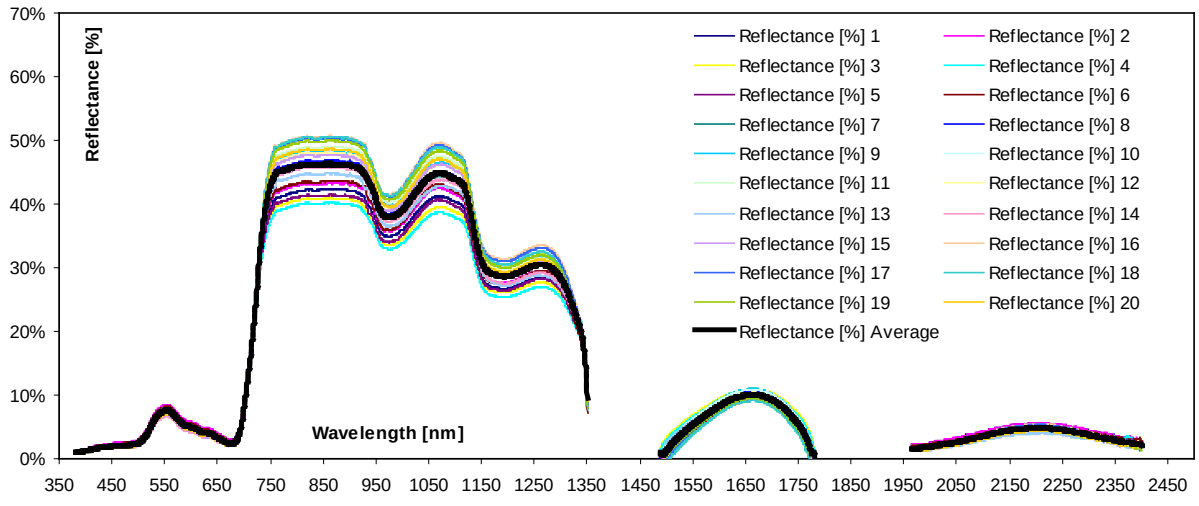


Testsite Neusling – Sample Point NZR2/2	
Date:	2009-07-27
Time [CEST]:	10:11
Easting [GK]:	^{45}64292
Northing [GK]:	^{53}95303
Height above Sea Level [m]:	346
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Reduced stand density
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	52.60
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.67
Soil Moisture [%]:	31.3
Wet aboveground biomass [g m^{-2}]	6316.22
Dry aboveground biomass [g m^{-2}]	868.89
Biomass water content [g m^{-2}]	5447.33
Biomass moisture [%]	86.24
Leaf Area Index	3.90
LAI std. Dev.	0.04

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

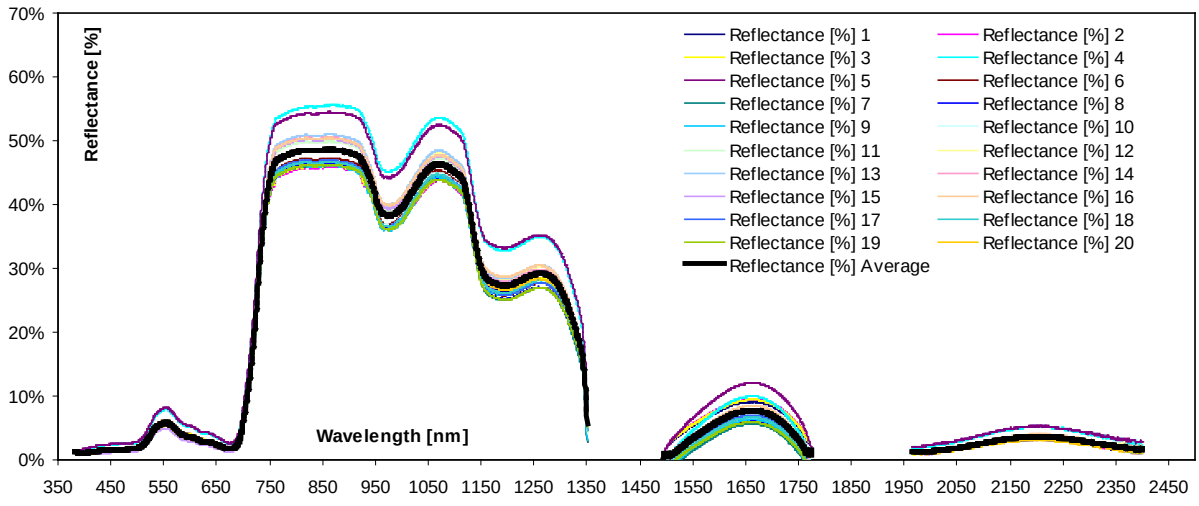


Testsite Neusling – Sample Point NZR2/3	
Date:	2009-07-27
Time [CEST]:	10:20
Easting [GK]:	^{45}64132
Northing [GK]:	^{53}95200
Height above Sea Level [m]:	347
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Extremely dense canopy
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	69.80
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	23.20
Wet aboveground biomass [g m^{-2}]	13897.56
Dry aboveground biomass [g m^{-2}]	1272.89
Biomass water content [g m^{-2}]	12624.67
Biomass moisture [%]	90.84
Leaf Area Index	5.95
LAI std. Dev.	0.81

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

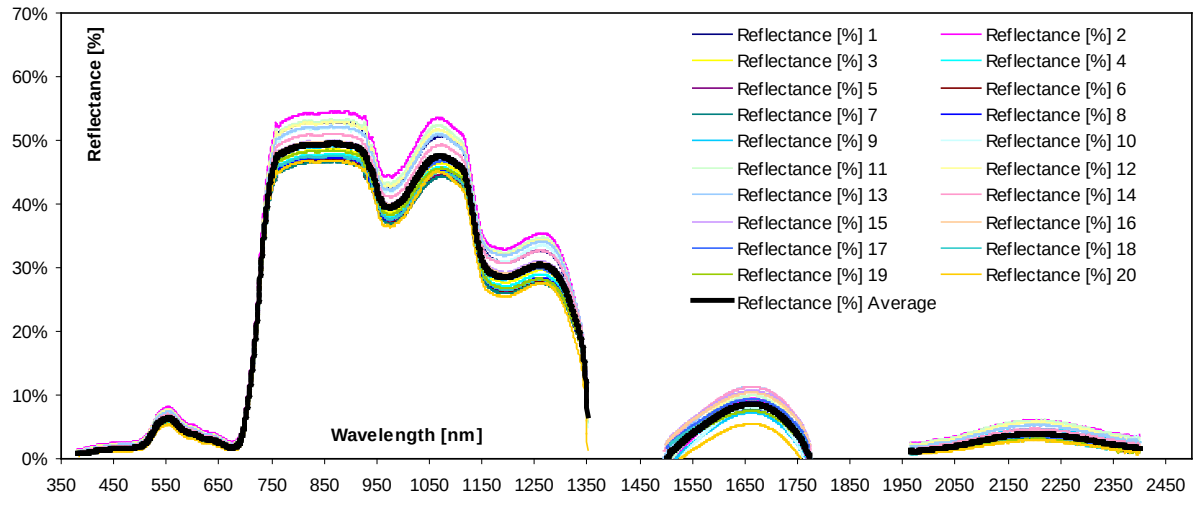


Testsite Neusling – Sample Point NZR2/4	
Date:	2009-07-27
Time [CEST]:	10:31
Easting [GK]:	^{45}64187
Northing [GK]:	^{53}95104
Height above Sea Level [m]:	347
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Patchy growth
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	57
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	30.63
Wet aboveground biomass [g m^{-2}]	8218
Dry aboveground biomass [g m^{-2}]	899.56
Biomass water content [g m^{-2}]	7318.44
Biomass moisture [%]	89.05
Leaf Area Index	5.56
LAI std. Dev.	0.03

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

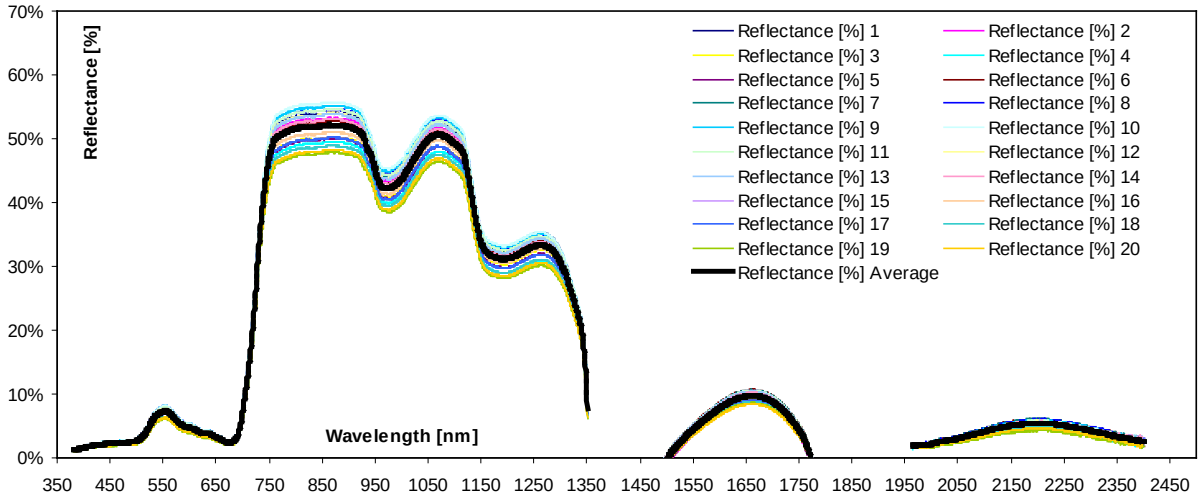


Testsite Neusling – Sample Point NZR2/5	
Date:	2009-07-27
Time [CEST]:	10:41
Easting [GK]:	^{45}64245
Northing [GK]:	^{53}95159
Height above Sea Level [m]:	345
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	No special observations
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	55
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	12.22
Soil Moisture [%]:	30.6
Wet aboveground biomass [g m^{-2}]	8853.11
Dry aboveground biomass [g m^{-2}]	928
Biomass water content [g m^{-2}]	7925.11
Biomass moisture [%]	89.52
Leaf Area Index	4.43
LAI std. Dev.	0.03

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

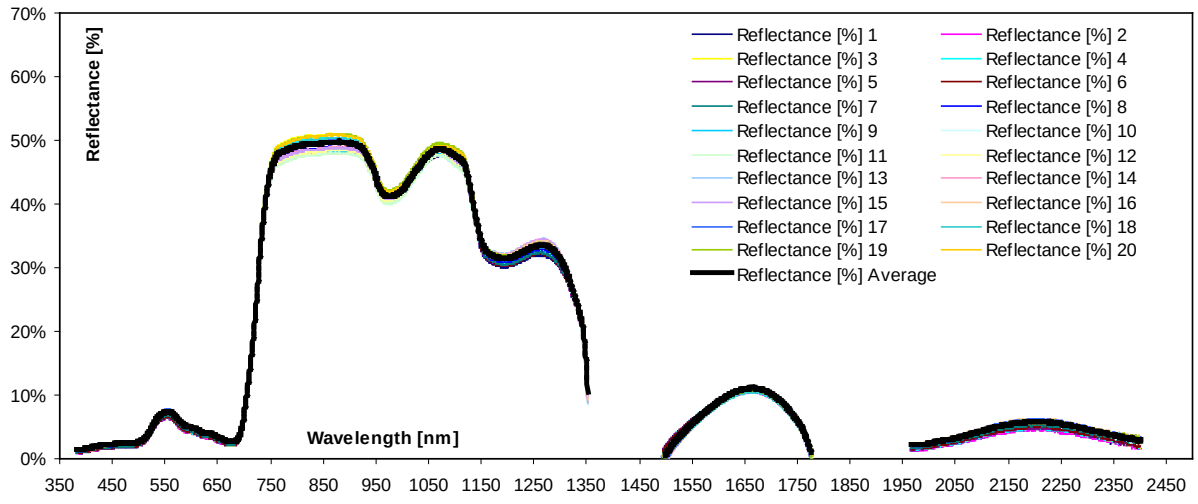


Testsite Neusling – Sample Point NZR3/1	
Date:	2009-07-27
Time [CEST]:	11:30
Easting [GK]:	^{45}64588
Northing [GK]:	^{53}95572
Height above Sea Level [m]:	343
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Remarkably small leaves
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	55.8
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	10
Soil Moisture [%]:	30.57
Wet aboveground biomass [g m^{-2}]	7888.89
Dry aboveground biomass [g m^{-2}]	790.22
Biomass water content [g m^{-2}]	7098.67
Biomass moisture [%]	89.98
Leaf Area Index	2.47
LAI std. Dev.	0.03

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



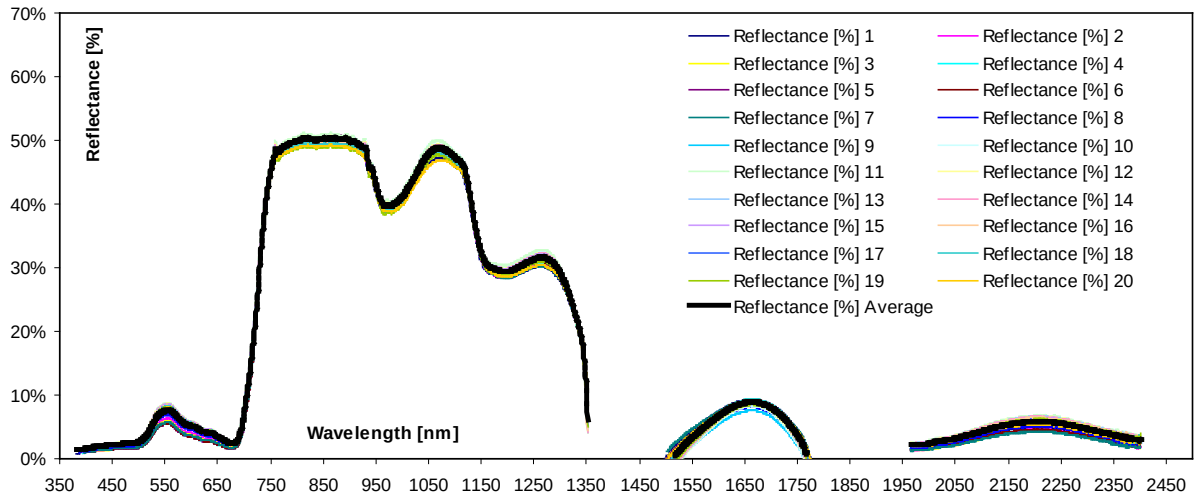
Testsite Neusling – Sample Point NZR3/2

Date:	2009-07-27
Time [CEST]:	11:41
Easting [GK]:	^{45}64561
Northing [GK]:	^{53}95613
Height above Sea Level [m]:	344
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Possibly tree shadowed
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	69.8
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	32.77
Wet aboveground biomass [g m^{-2}]	9790.22
Dry aboveground biomass [g m^{-2}]	1037.78
Biomass water content [g m^{-2}]	8752.44
Biomass moisture [%]	89.4
Leaf Area Index	3.19
LAI std. Dev.	0.03

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

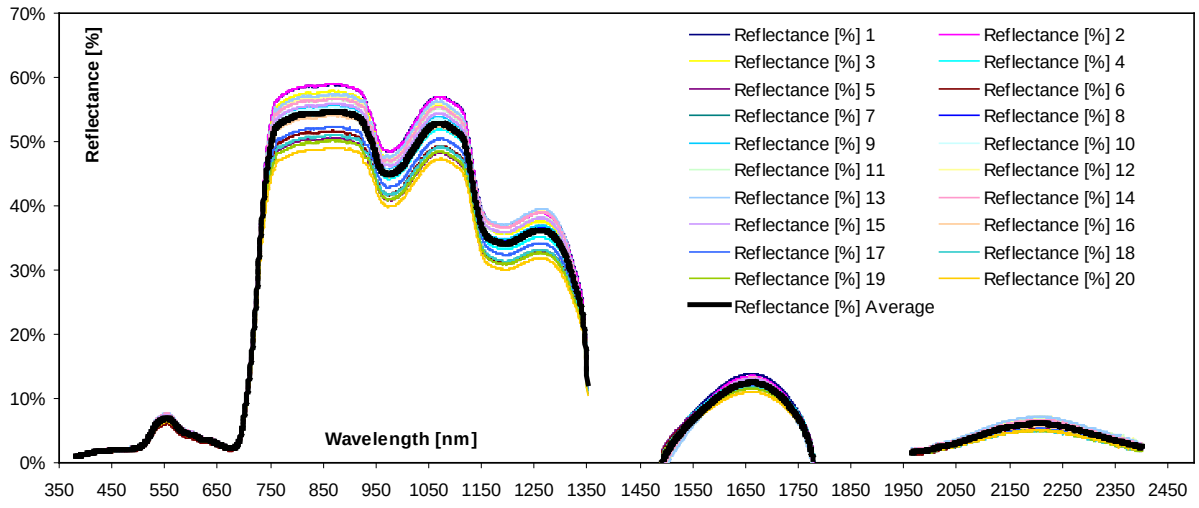


Testsite Neusling – Sample Point NZR3/3	
Date:	2009-07-27
Time [CEST]:	11:55
Easting [GK]:	^{45}64354
Northing [GK]:	^{53}95572
Height above Sea Level [m]:	343
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Canopy more dense
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	65.6
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	31.07
Wet aboveground biomass [g m^{-2}]	7812.44
Dry aboveground biomass [g m^{-2}]	840.44
Biomass water content [g m^{-2}]	6972
Biomass moisture [%]	89.24
Leaf Area Index	3.79
LAI std. Dev.	0.03

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



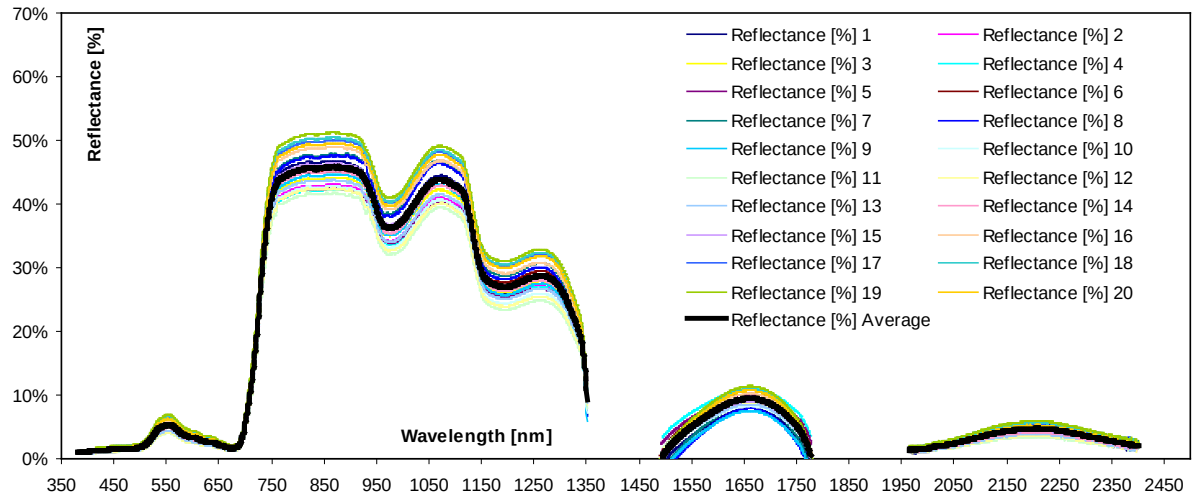
Testsite Neusling – Sample Point NZR3/4

Date:	2009-07-27
Time [CEST]:	12:05
Easting [GK]:	^{45}64393
Northing [GK]:	^{53}95488
Height above Sea Level [m]:	346
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Bleached leaves
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	62.4
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	28.67
Wet aboveground biomass [g m^{-2}]	8023.56
Dry aboveground biomass [g m^{-2}]	866.67
Biomass water content [g m^{-2}]	7156.89
Biomass moisture [%]	89.2
Leaf Area Index	4.52
LAI std. Dev.	0.15

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

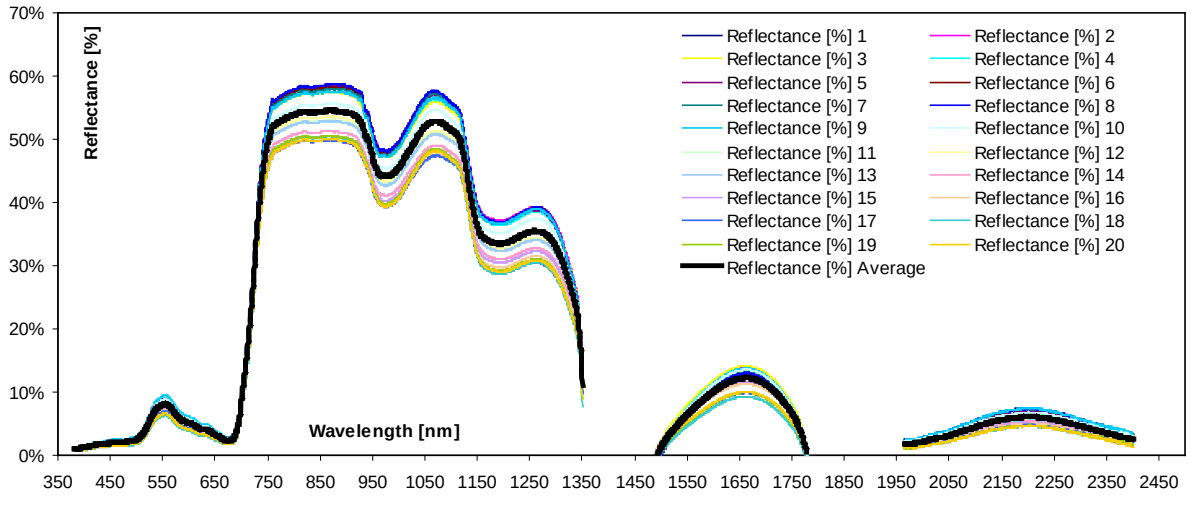


Testsite Neusling – Sample Point NZR3/5	
Date:	2009-07-27
Time [CEST]:	12:12
Easting [GK]:	^{45}64463
Northing [GK]:	^{53}95542
Height above Sea Level [m]:	341
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Much weed
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	62.4
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	12.22
Soil Moisture [%]:	26.3
Wet aboveground biomass [g m^{-2}]	8537.78
Dry aboveground biomass [g m^{-2}]	868.44
Biomass water content [g m^{-2}]	7669.33
Biomass moisture [%]	89.83
Leaf Area Index	4.27
LAI std. Dev.	0.05

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

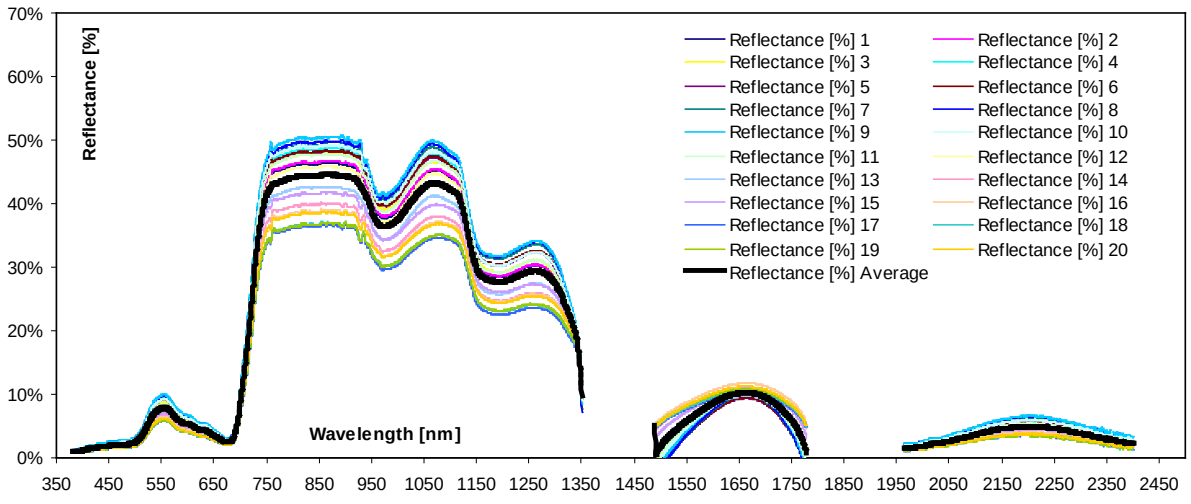


Testsite Neusling – Sample Point NZR4/1		
Date:	2009-07-27	
Time [CEST]:	12:47	
Easting [GK]:	^{45}64548	
Northing [GK]:	^{53}95693	
Height above Sea Level [m]:	340	
Landcover [IGGF Code]:	304 (sugar beet)	
Phenology [BBCH]:	54	
Observation:	No special observations	
Weather:	Smooth wind; 1/8 clouds	
Canopy Height [cm]:	55.4	
Row distance [cm]:	45	
Plant density [Plt. m^{-2}]:	11.67	
Soil Moisture [%]:	32.2	
Wet aboveground biomass [g m^{-2}]	5264.89	
Dry aboveground biomass [g m^{-2}]	583.56	
Biomass water content [g m^{-2}]	4681.33	
Biomass moisture [%]	88.92	
Leaf Area Index	2.28	
LAI std. Dev.	0.02	

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

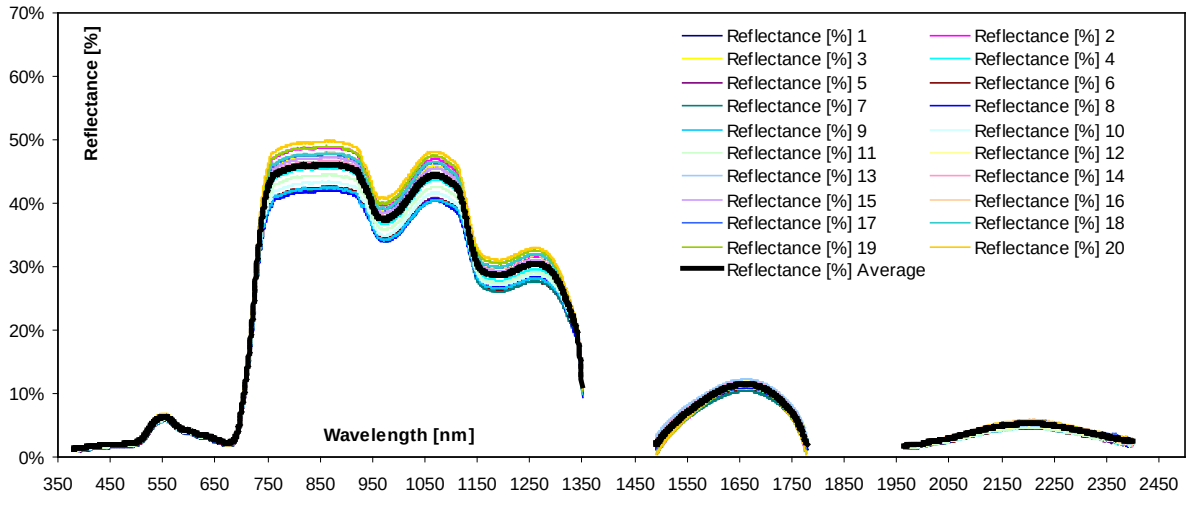


Testsite Neusling – Sample Point NZR4/2	
Date:	2009-07-27
Time [CEST]:	13:00
Easting [GK]:	^{45}64486
Northing [GK]:	^{53}95666
Height above Sea Level [m]:	341
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Patchy growth
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	59.4
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	29.37
Wet aboveground biomass [g m^{-2}]	5056.89
Dry aboveground biomass [g m^{-2}]	593.78
Biomass water content [g m^{-2}]	4463.11
Biomass moisture [%]	88.26
Leaf Area Index	2.86
LAI std. Dev.	0.07

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



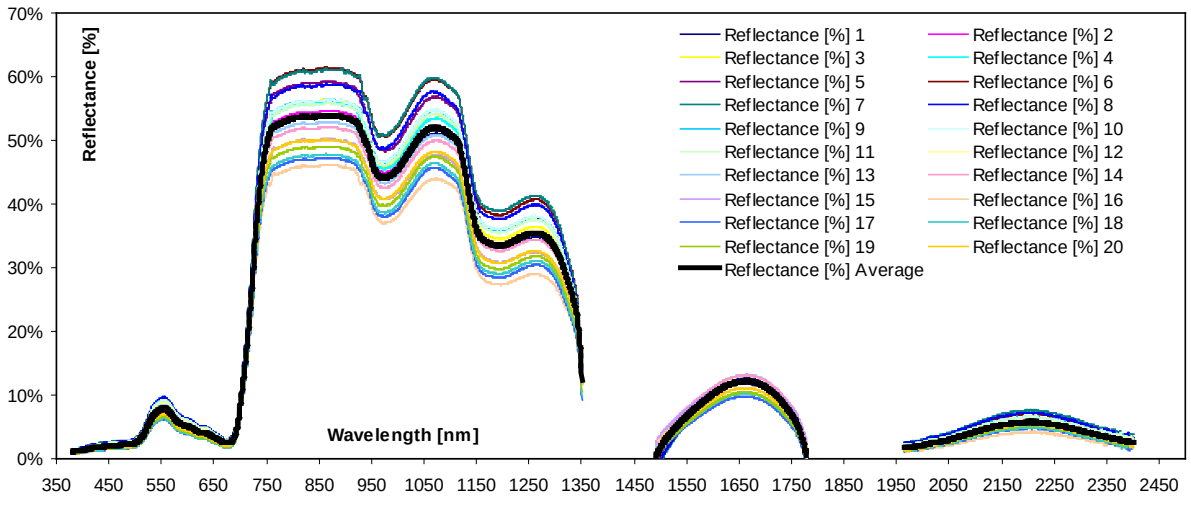
Testsite Neusling – Sample Point NZR4/3

Date:	2009-07-27
Time [CEST]:	13:13
Easting [GK]:	^{45}64419
Northing [GK]:	^{53}95647
Height above Sea Level [m]:	343
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Patchy growth
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	55.80
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	12.22
Soil Moisture [%]:	26.33
Wet aboveground biomass [g m^{-2}]	5988
Dry aboveground biomass [g m^{-2}]	668.44
Biomass water content [g m^{-2}]	5319.56
Biomass moisture [%]	88.84
Leaf Area Index	3.64
LAI std. Dev.	0.02

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



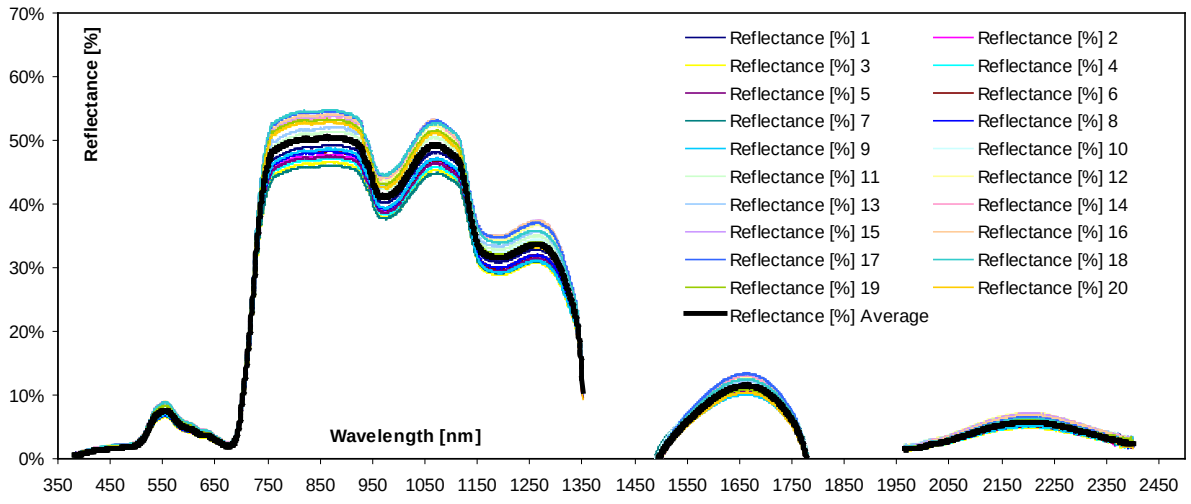
Testsite Neusling – Sample Point NZR4/4

Date:	2009-07-27
Time [CEST]:	13:25
Easting [GK]:	^{45}64309
Northing [GK]:	^{53}95610
Height above Sea Level [m]:	345
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Grassy weeds
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	58
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	28.87
Wet aboveground biomass [g m^{-2}]	8008.44
Dry aboveground biomass [g m^{-2}]	995.56
Biomass water content [g m^{-2}]	7012.89
Biomass moisture [%]	87.57
Leaf Area Index	2.84
LAI std. Dev.	0.06

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

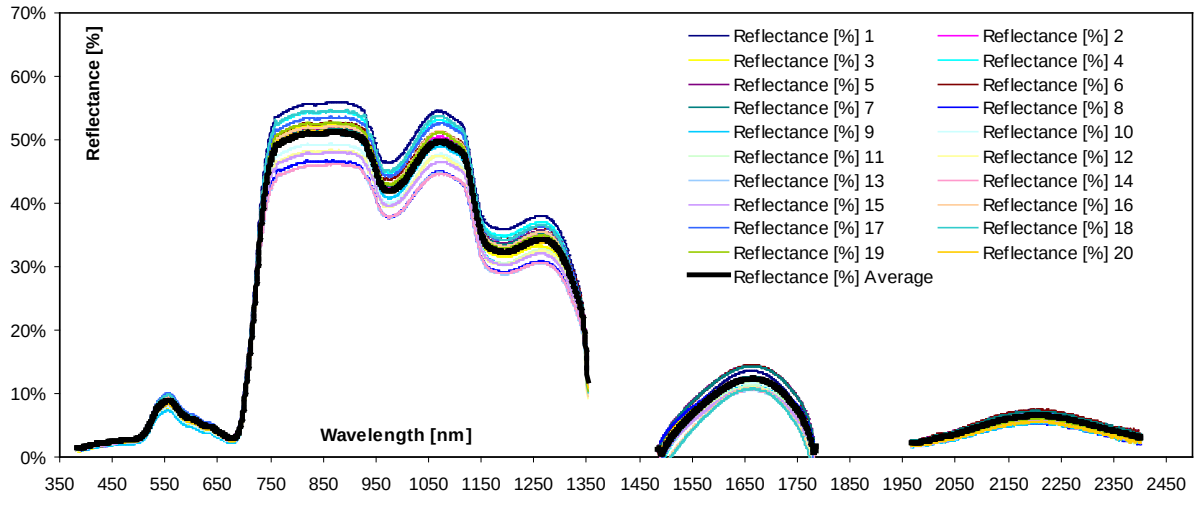


Testsite Neusling – Sample Point NZR4/5	
Date:	2009-07-27
Time [CEST]:	13:42
Easting [GK]:	^{45}64212
Northing [GK]:	^{53}95583
Height above Sea Level [m]:	340
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	54
Observation:	Grassy weeds
Weather:	Smooth wind; 1/8 clouds
Canopy Height [cm]:	62.8
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	29.1
Wet aboveground biomass [g m^{-2}]	6550.22
Dry aboveground biomass [g m^{-2}]	637.33
Biomass water content [g m^{-2}]	5912.89
Biomass moisture [%]	90.27
Leaf Area Index	3.03
LAI std. Dev.	0

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



Testsite Neusling – Sample Point NM1

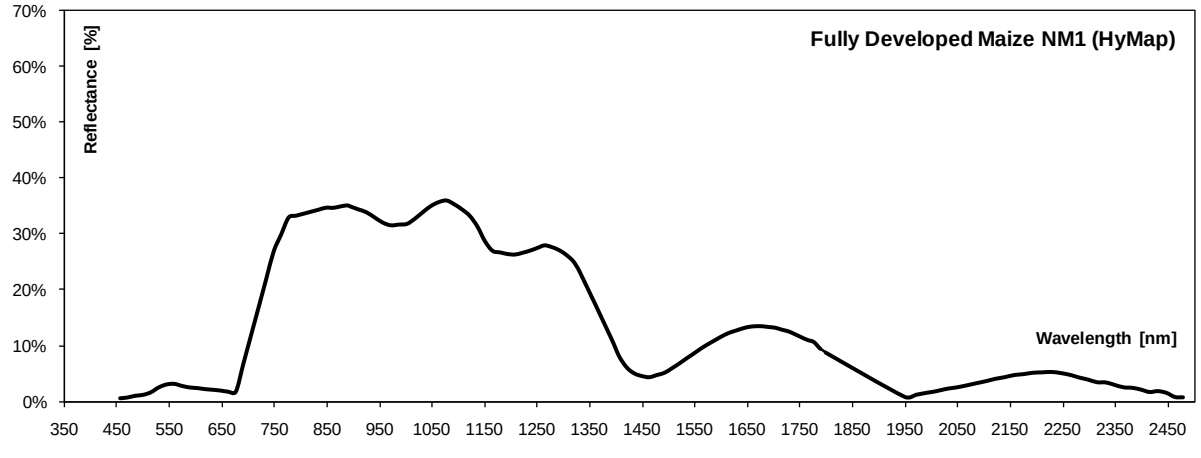
Date:	2009-07-27
Time [CEST]:	15:08
Easting [GK]:	^{45}65612
Northing [GK]:	^{53}96394
Height above Sea Level [m]:	335
Landcover [IGGF Code]:	109 (Maize silage)
Phenology [BBCH]:	73
Observation:	Lots of Fauna: Spiders, Caterpillars etc.
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	282
Row distance [cm]:	80
Plant density [Plt. m^{-2}]:	8.75
Soil Moisture [%]:	26.33
Wet aboveground biomass [g m^{-2}]	5986.6
Dry aboveground biomass [g m^{-2}]	1028.71
Biomass water content [g m^{-2}]	4957.9
Biomass moisture [%]	82.82
Leaf Area Index	2.72
LAI std. Dev.	0.02

Vertical Photograph

Sorry, no picture…

Horizontal Photograph

HyMap [Abs. Reflectance]:

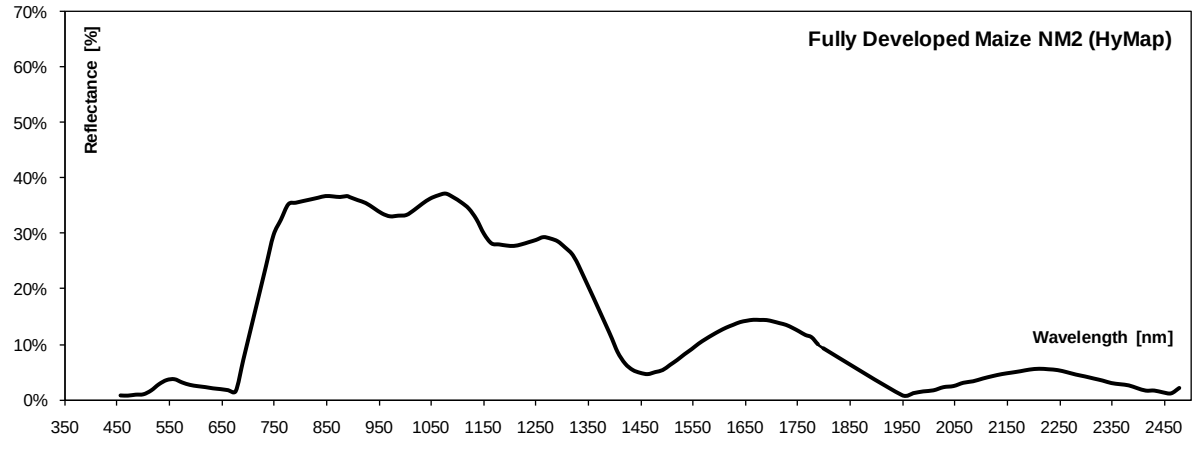


Testsite Neusling – Sample Point NM2	
Date:	2009-07-27
Time [CEST]:	15:25
Easting [GK]:	^{45}65633
Northing [GK]:	^{53}96762
Height above Sea Level [m]:	333
Landcover [IGGF Code]:	109 (Maize silage)
Phenology [BBCH]:	73
Observation:	Lots of Fauna: Spiders, Caterpillars etc.
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	284.8
Row distance [cm]:	80
Plant density [Plt. m^{-2}]:	8.13
Soil Moisture [%]:	25.07
Wet aboveground biomass [g m^{-2}]	5983.39
Dry aboveground biomass [g m^{-2}]	1118.81
Biomass water content [g m^{-2}]	4864.57
Biomass moisture [%]	81.3
Leaf Area Index	2.97
LAI std. Dev.	0.01

Vertical Photograph

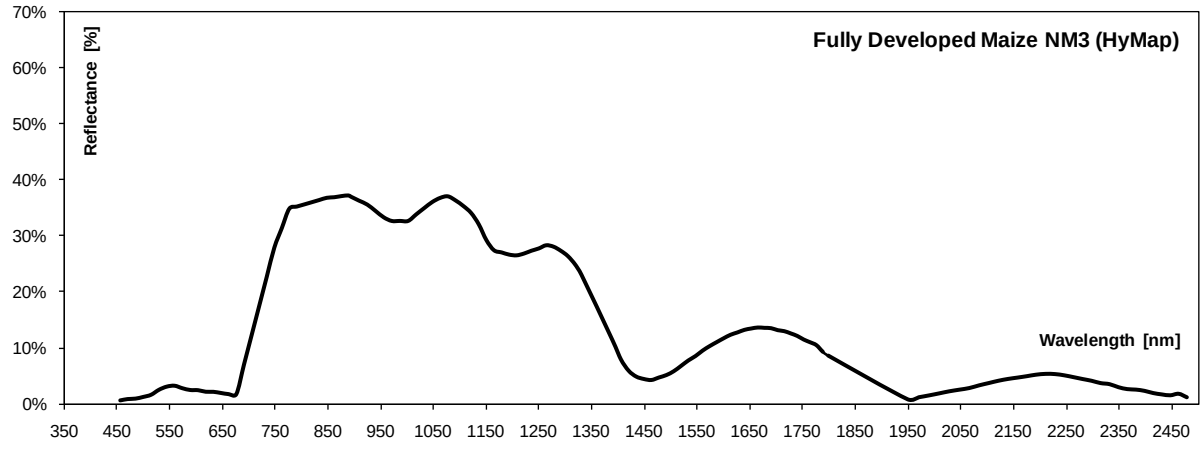
Horizontal Photograph

HyMap [Abs. Reflectance]:



Testsite Neusling – Sample Point NM3		
Date:	2009-07-27	
Time [CEST]:	15:40	
Easting [GK]:	^{45}65885	
Northing [GK]:	^{53}96403	
Height above Sea Level [m]:	336	
Landcover [IGGF Code]:	109 (Maize silage)	Vertical Photograph
Phenology [BBCH]:	73	
Observation:	Cool microclimate	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	306.4	
Row distance [cm]:	78	
Plant density [Plt. m^{-2}]:	8.97	
Soil Moisture [%]:	29.4	
Wet aboveground biomass [g m^{-2}]	9676.15	Sorry, no picture…
Dry aboveground biomass [g m^{-2}]	1689.87	
Biomass water content [g m^{-2}]	7986.28	
Biomass moisture [%]	82.54	
Leaf Area Index	3.22	Horizontal Photograph
LAI std. Dev.	0.02	

HyMap [Abs. Reflectance]:

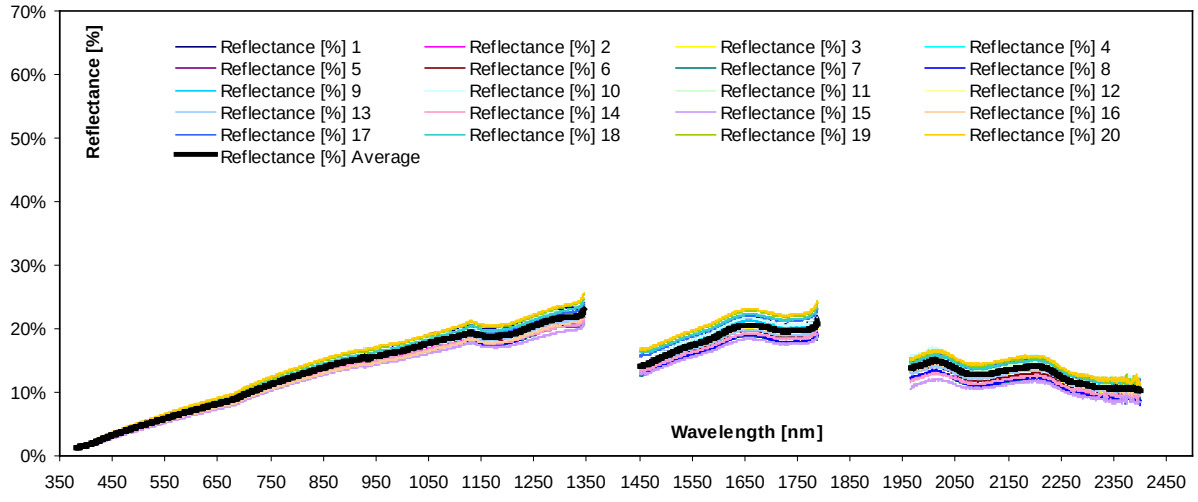


Testsite Neusling – Sample Point NW1	
Date:	2009-07-27
Time [CEST]:	16:10
Easting [GK]:	^{45}64154
Northing [GK]:	^{53}95574
Height above Sea Level [m]:	346
Landcover [IGGF Code]:	101 (winter wheat)
Phenology [BBCH]:	93
Observation:	No special observations
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	69.6
Row distance [cm]:	25
Plant density [Plt. m^{-2}]:	448
Soil Moisture [%]:	25.97
Wet aboveground biomass [g m^{-2}]	1590
Dry aboveground biomass [g m^{-2}]	558.4
Biomass water content [g m^{-2}]	1031.6
Biomass moisture [%]	64.88
Leaf Area Index	2.01
LAI std. Dev.	0.0

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



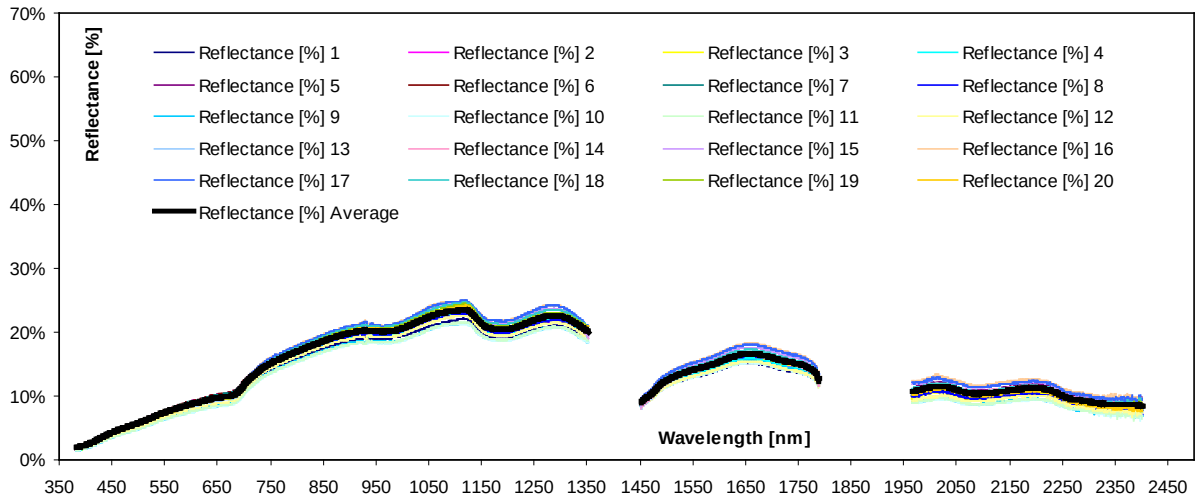
Testsite Neusling – Sample Point NW2

Date:	2009-07-27
Time [CEST]:	16:30
Easting [GK]:	^{45}63932
Northing [GK]:	^{53}96076
Height above Sea Level [m]:	341
Landcover [IGGF Code]:	101 (winter wheat)
Phenology [BBCH]:	93
Observation:	No special observations
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	95.2
Row distance [cm]:	25
Plant density [Plt. m^{-2}]:	420
Soil Moisture [%]:	26.37
Wet aboveground biomass [g m^{-2}]	1547.6
Dry aboveground biomass [g m^{-2}]	972
Biomass water content [g m^{-2}]	575.6
Biomass moisture [%]	37.19
Leaf Area Index	1.65
LAI std. Dev.	0.04

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

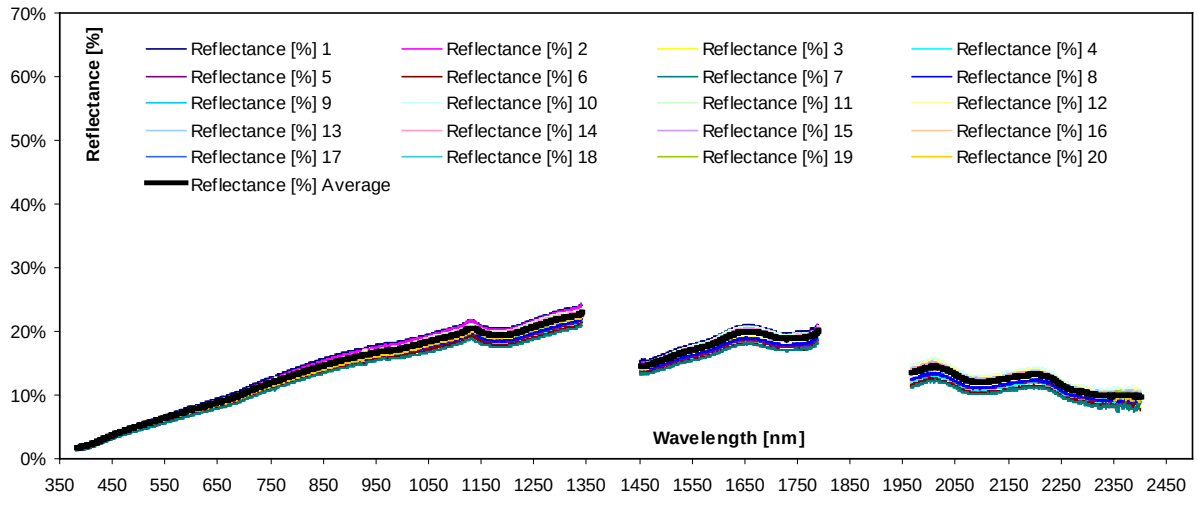


Testsite Neusling – Sample Point NW3	
Date:	2009-07-27
Time [CEST]:	16:46
Easting [GK]:	^{45}63929
Northing [GK]:	^{53}95578
Height above Sea Level [m]:	345
Landcover [IGGF Code]:	101 (winter wheat)
Phenology [BBCH]:	93
Observation:	No special observations
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	78.6
Row distance [cm]:	25
Plant density [Plt. m^{-2}]:	620
Soil Moisture [%]:	21.83
Wet aboveground biomass [g m^{-2}]	1699.6
Dry aboveground biomass [g m^{-2}]	1400.8
Biomass water content [g m^{-2}]	298.8
Biomass moisture [%]	17.58
Leaf Area Index	2.02
LAI std. Dev.	0.02

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:



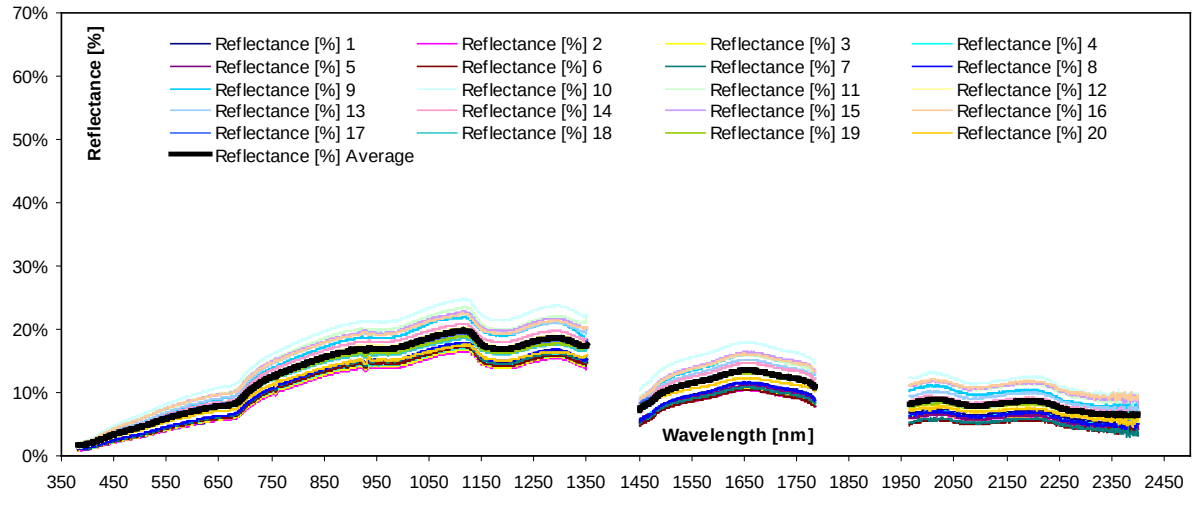
Testsite Neusling – Sample Point NW4

Date:	2009-07-27
Time [CEST]:	17:00
Easting [GK]:	4563708
Northing [GK]:	5396073
Height above Sea Level [m]:	345
Landcover [IGGF Code]:	101 (winter wheat)
Phenology [BBCH]:	87
Observation:	No special observations
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	93.2
Row distance [cm]:	25
Plant density [Plt. m^{-2}]:	412
Soil Moisture [%]:	25.87
Wet aboveground biomass [g m^{-2}]	1613.2
Dry aboveground biomass [g m^{-2}]	1104
Biomass water content [g m^{-2}]	509.2
Biomass moisture [%]	31.56
Leaf Area Index	1.76
LAI std. Dev.	0.02

Vertical Photograph

Horizontal Photograph

ASD FieldSpec3-JR [Abs. Reflectance]:

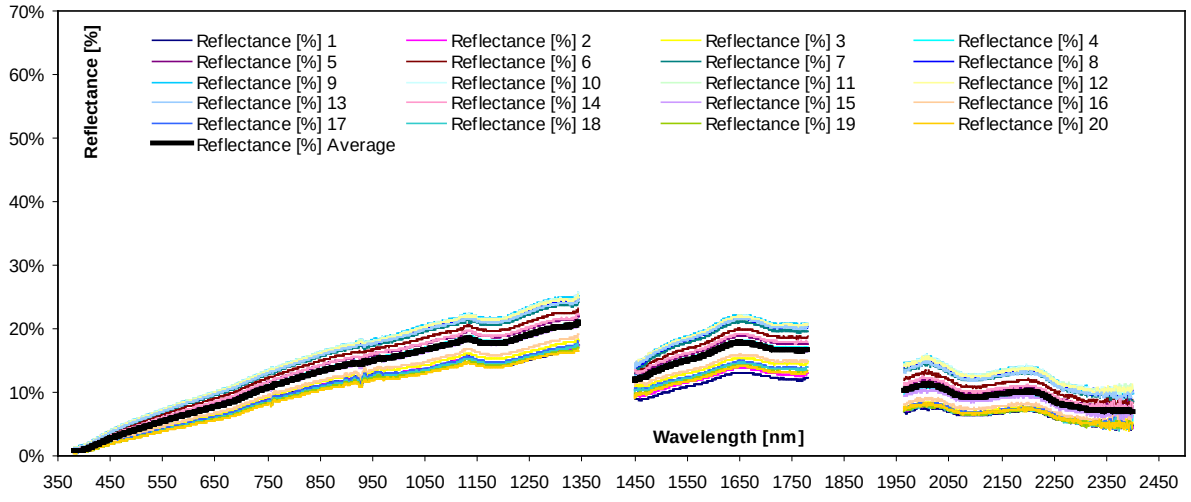


Testsite Neusling – Sample Point NW5	
Date:	2009-07-27
Time [CEST]:	17:20
Easting [GK]:	^{45}64027
Northing [GK]:	^{53}95904
Height above Sea Level [m]:	349
Landcover [IGGF Code]:	101 (winter wheat)
Phenology [BBCH]:	92
Observation:	No special observations
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	81
Row distance [cm]:	25
Plant density [Plt. m^{-2}]:	560
Soil Moisture [%]:	30.53
Wet aboveground biomass [g m^{-2}]	1458
Dry aboveground biomass [g m^{-2}]	1140.8
Biomass water content [g m^{-2}]	317.2
Biomass moisture [%]	21.76
Leaf Area Index	3.19
LAI std. Dev.	0.02

Vertical Photograph

Horizontal Photograph

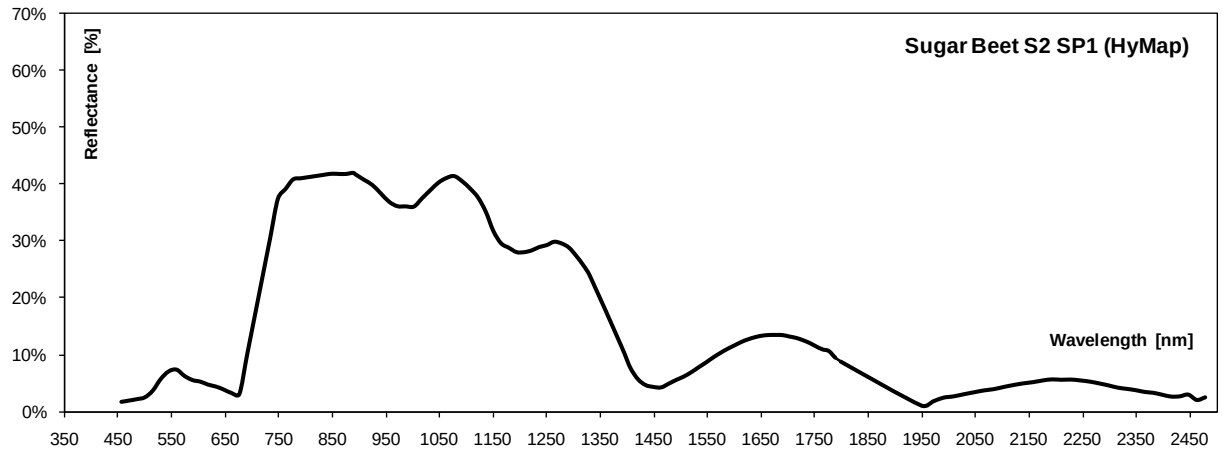
ASD FieldSpec3-JR [Abs. Reflectance]:



10.10 Data sheets of the 'Steinbeißen' test area

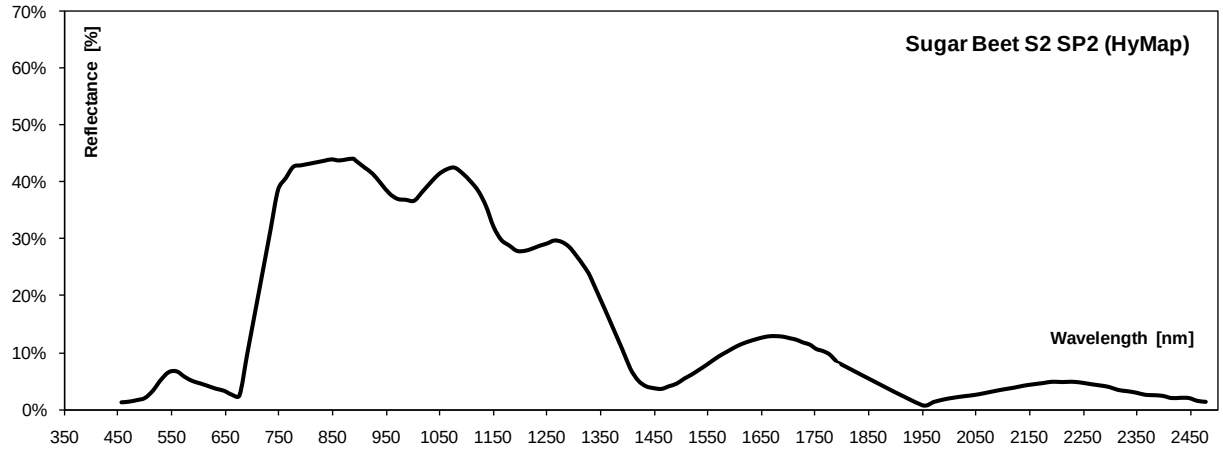
Testsite Steinbeißen – Sample Point S2SP1		
Date:	2009-07-27	
Time [CEST]:	08:58	
Easting [GK]:	^{45}54148	
Northing [GK]:	^{53}86156	
Height above Sea Level [m]:	342	
Landcover [IGGF Code]:	304 (sugar beet)	Sorry, no picture…
Phenology [BBCH]:	85	
Observation:	Slopes S (high) to N (low)	
Weather:	No wind; 0/8 - 1/8 clouds	
Canopy Height [cm]:	55	Vertical Photograph
Row distance [cm]:	45	
Plant density [Plt. m^{-2}]:	11.11	
Soil Moisture [%]:	30.02	
Wet aboveground biomass [g m^{-2}]	8538.89	
Dry aboveground biomass [g m^{-2}]	945.33	
Biomass water content [g m^{-2}]	7593.56	
Biomass moisture [%]	88.93	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



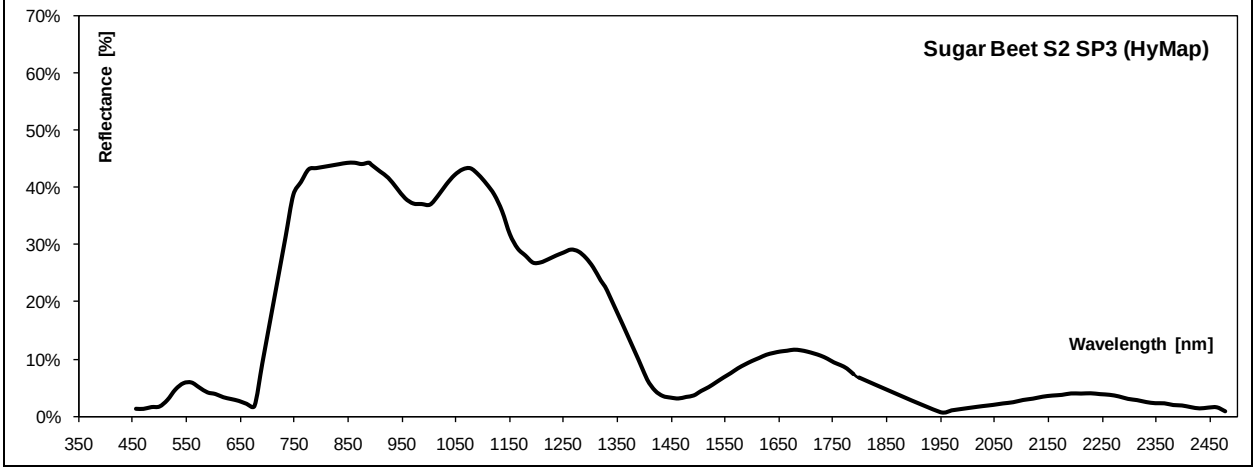
Testsite Steinbeißen – Sample Point S2SP2		
Date:	2009-07-27	Sorry, no picture…
Time [CEST]:	09:21	
Easting [GK]:	^{45}54127	
Northing [GK]:	^{53}86227	
Height above Sea Level [m]:	263	
Landcover [IGGF Code]:	304 (sugar beet)	
Phenology [BBCH]:	85	
Observation:	No special observations	
Weather:	No wind; 0/8 - 1/8 clouds	
Canopy Height [cm]:	50	Vertical Photograph
Row distance [cm]:	45	
Plant density [Plt. m^{-2}]:	12.22	
Soil Moisture [%]:	30.6	
Wet aboveground biomass [g m^{-2}]	6381.11	
Dry aboveground biomass [g m^{-2}]	718.22	
Biomass water content [g m^{-2}]	5662.89	
Biomass moisture [%]	88.74	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



Testsite Steinbeißen – Sample Point S2SP3		
Date:	2009-07-27	
Time [CEST]:	09:28	
Easting [GK]:	^{45}54116	
Northing [GK]:	^{53}86285	
Height above Sea Level [m]:	364	
Landcover [IGGF Code]:	304 (sugar beet)	Sorry, no picture…
Phenology [BBCH]:	85	
Observation:	Slight depression; dewy	
Weather:	No wind; 0/8 - 1/8 clouds	
Canopy Height [cm]:	61	Vertical Photograph
Row distance [cm]:	45	
Plant density [Plt. m^{-2}]:	12.22	
Soil Moisture [%]:	35.86	
Wet aboveground biomass [g m^{-2}]	9065.56	
Dry aboveground biomass [g m^{-2}]	1103.56	
Biomass water content [g m^{-2}]	7962	
Biomass moisture [%]	87.83	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



Testsite Steinbeißen – Sample Point S2SP4

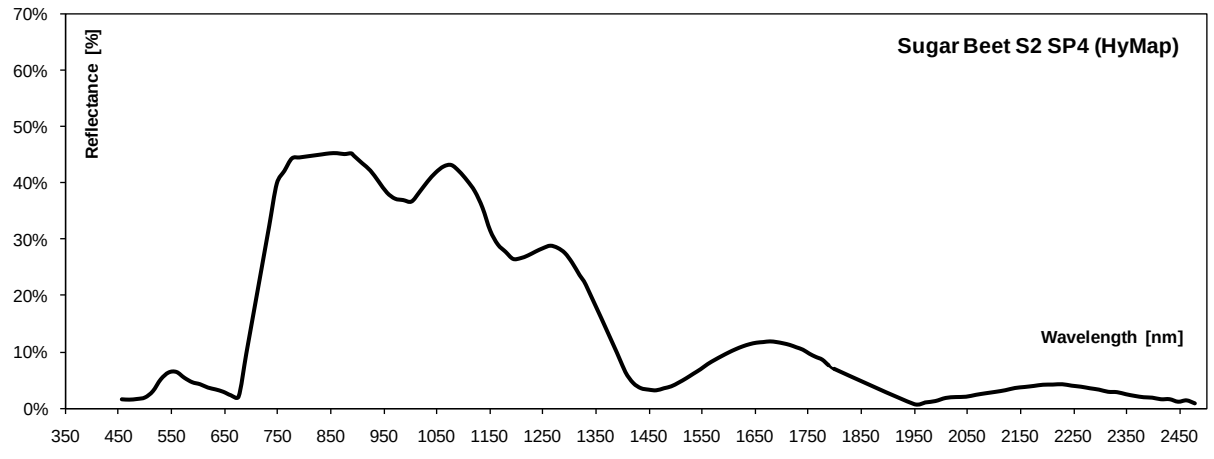
Date:	2009-07-27
Time [CEST]:	09:41
Easting [GK]:	^{45}54072
Northing [GK]:	^{53}86484
Height above Sea Level [m]:	366
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	85
Observation:	No special observations
Weather:	No wind; 0/8 - 1/8 clouds
Canopy Height [cm]:	63
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	34.98
Wet aboveground biomass [g m^{-2}]	11396.22
Dry aboveground biomass [g m^{-2}]	1305.78
Biomass water content [g m^{-2}]	10090.44
Biomass moisture [%]	88.54
Leaf Area Index	-
LAI std. Dev.	-

Sorry, no picture…

Vertical Photograph

Horizontal Photograph

HyMap [Abs. Reflectance]:

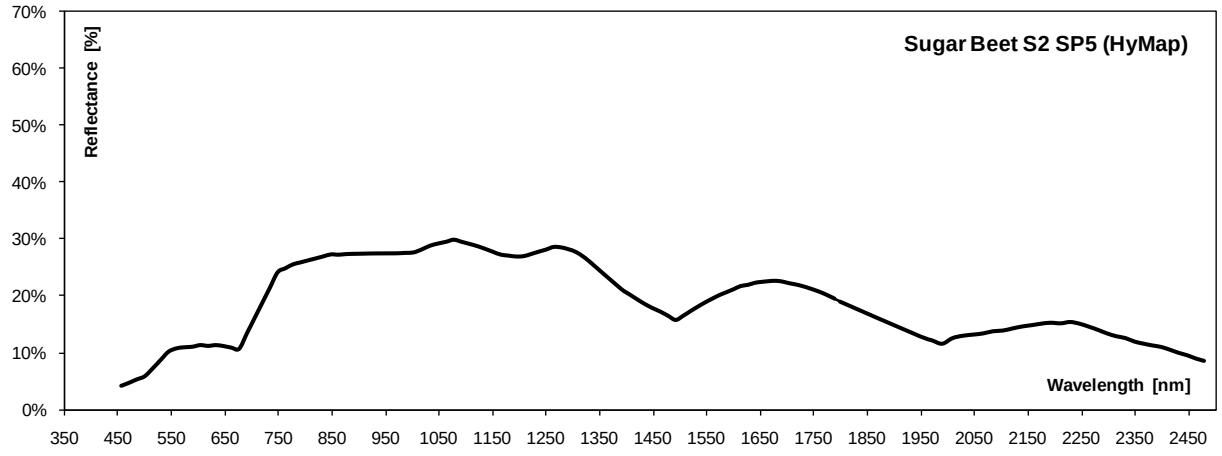


Testsite Steinbeißen – Sample Point S2SP5	
Date:	2009-07-27
Time [CEST]:	09:50
Easting [GK]:	^{45}54047
Northing [GK]:	^{53}86572
Height above Sea Level [m]:	368
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	85
Observation:	Probably water clogged; spare plant cover
Weather:	No wind; 0/8 - 1/8 clouds
Canopy Height [cm]:	40
Row distance [cm]:	45
Plant density [Plt. m^{-2}]:	11.11
Soil Moisture [%]:	37.66
Wet aboveground biomass [g m^{-2}]	5672.22
Dry aboveground biomass [g m^{-2}]	876.44
Biomass water content [g m^{-2}]	4795.78
Biomass moisture [%]	84.55
Leaf Area Index	-
LAI std. Dev.	-

Vertical Photograph

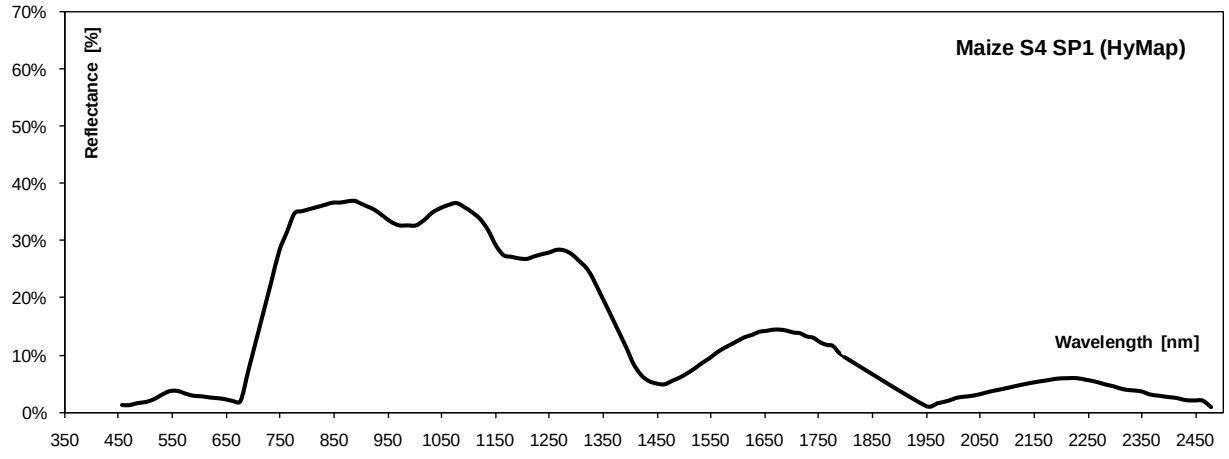
Horizontal Photograph

HyMap [Abs. Reflectance]:



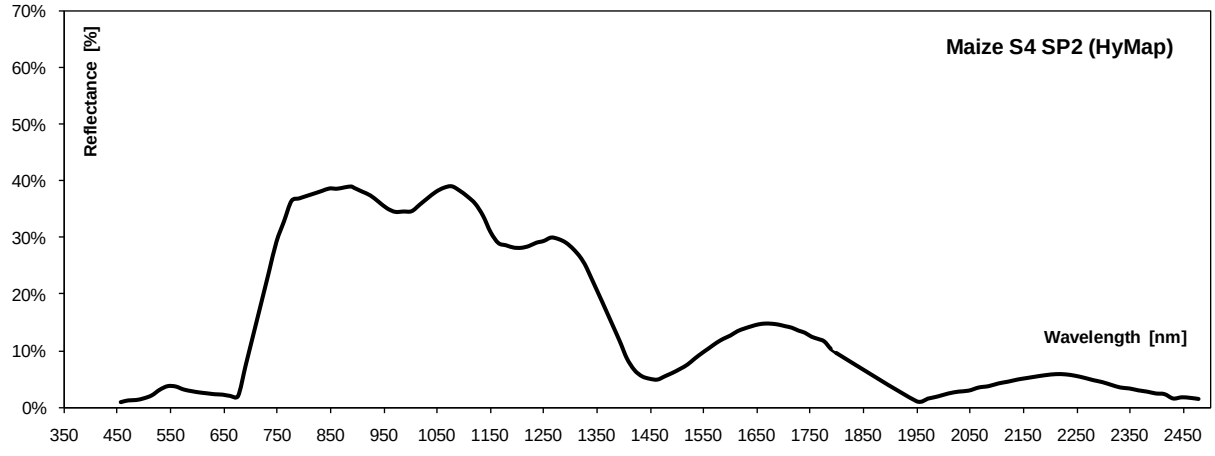
Testsite Steinbeißen – Sample Point S4SP1		
Date:	2009-07-27	
Time [CEST]:	11:52	
Easting [GK]:	^{45}54075	
Northing [GK]:	^{53}85843	
Height above Sea Level [m]:	385	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	305	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	7.33	
Soil Moisture [%]:	32.23	
Wet aboveground biomass [g m^{-2}]	8674.72	
Dry aboveground biomass [g m^{-2}]	1569.82	
Biomass water content [g m^{-2}]	7104.9	
Biomass moisture [%]	81.90	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



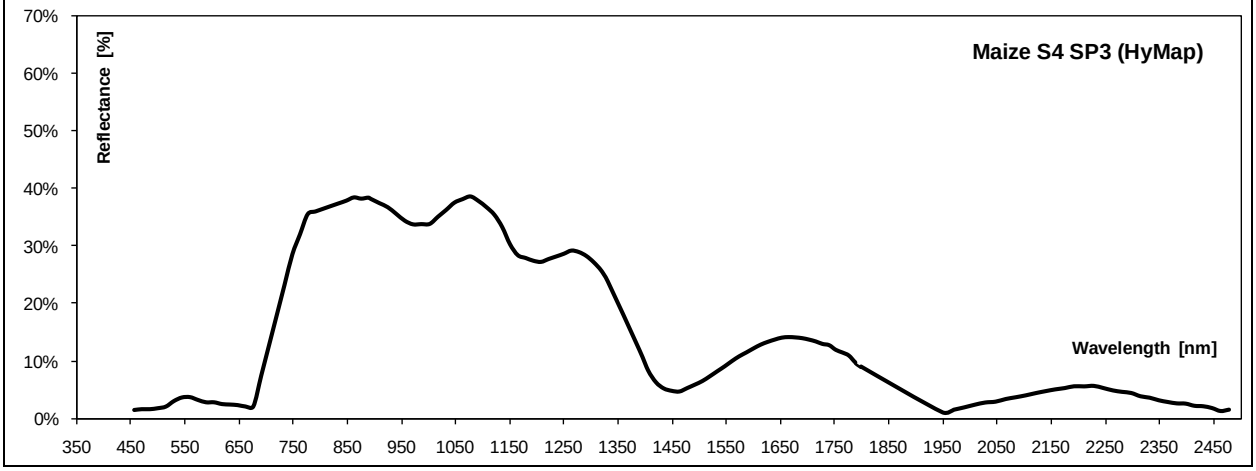
Testsite Steinbeißen – Sample Point S4SP2		
Date:	2009-07-27	
Time [CEST]:	12:25	
Easting [GK]:	^{45}54153	
Northing [GK]:	^{53}85979	
Height above Sea Level [m]:	383	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	315	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	8.67	
Soil Moisture [%]:	29.33	
Wet aboveground biomass [g m^{-2}]	8385.72	
Dry aboveground biomass [g m^{-2}]	1396.49	
Biomass water content [g m^{-2}]	6989.23	
Biomass moisture [%]	83.35	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



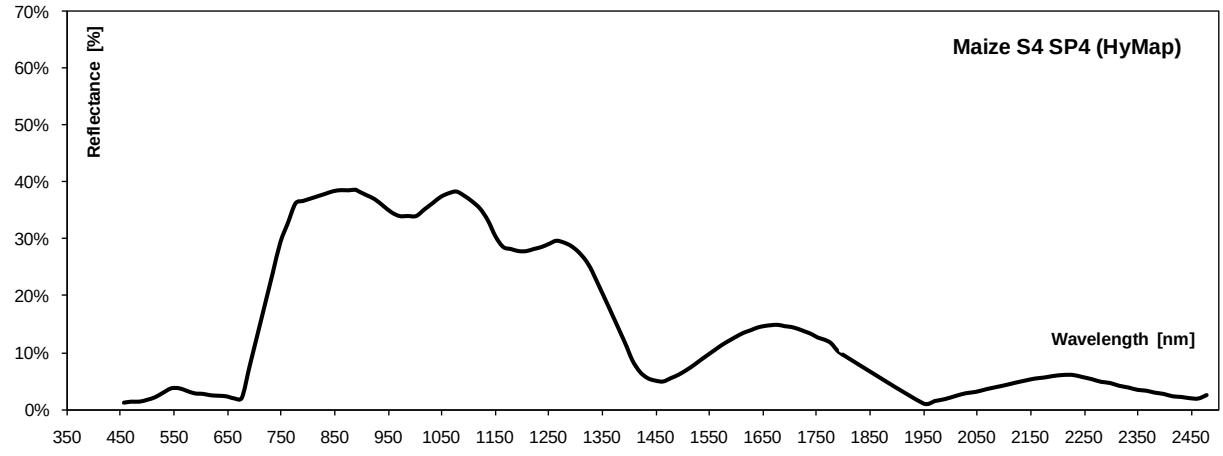
Testsite Steinbeißen – Sample Point S4SP3		
Date:	2009-07-27	
Time [CEST]:	12:40	
Easting [GK]:	^{45}54120	
Northing [GK]:	^{53}86078	
Height above Sea Level [m]:	381	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	310	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	8.67	
Soil Moisture [%]:	32.9	
Wet aboveground biomass [g m^{-2}]	9400.01	
Dry aboveground biomass [g m^{-2}]	1657.36	
Biomass water content [g m^{-2}]	7742.66	
Biomass moisture [%]	82.37	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



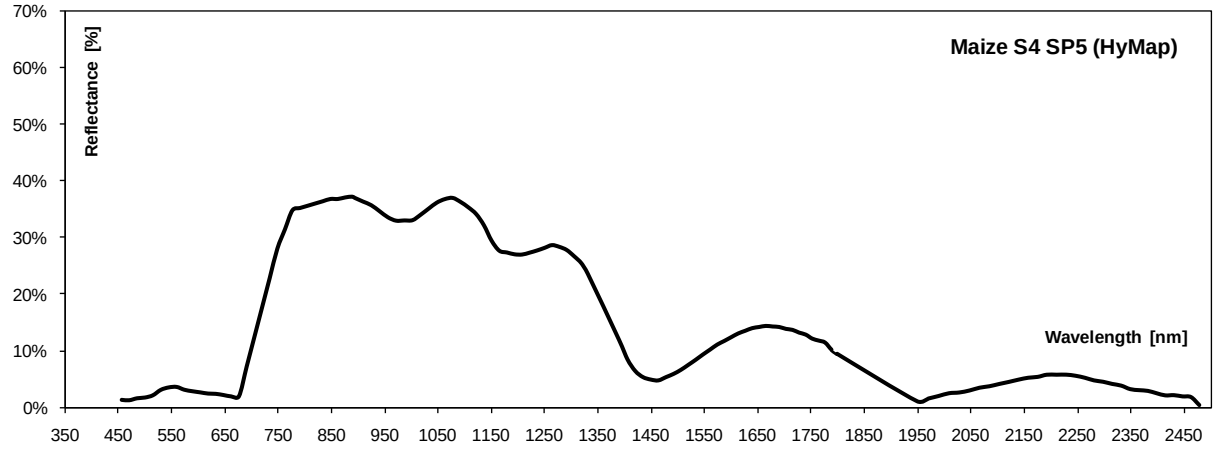
Testsite Steinbeißen – Sample Point S4SP4		
Date:	2009-07-27	
Time [CEST]:	14:34	
Easting [GK]:	^{45}54080	
Northing [GK]:	^{53}86059	
Height above Sea Level [m]:	380	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	310	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	7.33	
Soil Moisture [%]:	27.73	
Wet aboveground biomass [g m^{-2}]	8374.06	
Dry aboveground biomass [g m^{-2}]	1478.16	
Biomass water content [g m^{-2}]	6895.9	
Biomass moisture [%]	82.35	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



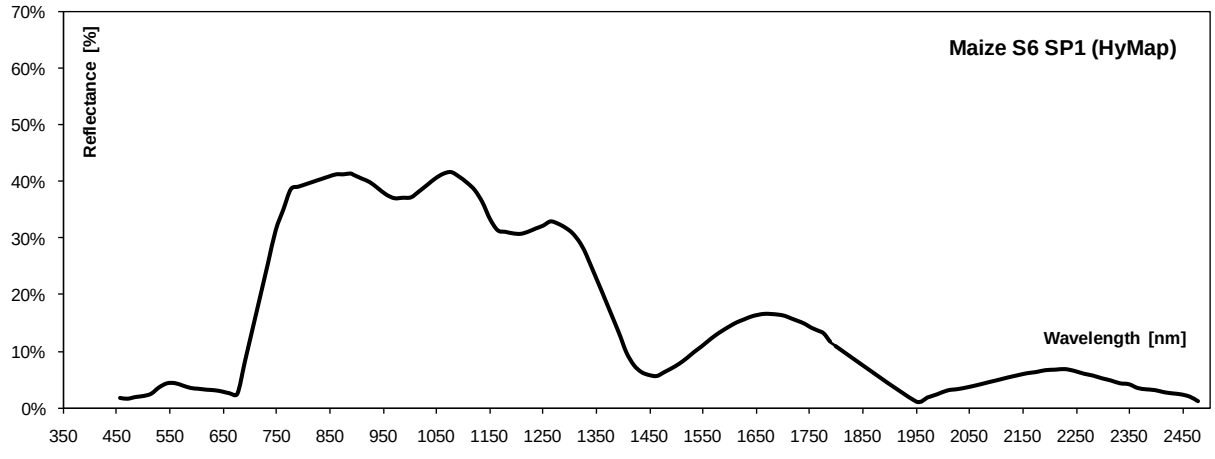
Testsite Steinbeißen – Sample Point S4SP5		
Date:	2009-07-27	
Time [CEST]:	14:50	
Easting [GK]:	^{45}54077	
Northing [GK]:	^{53}85988	
Height above Sea Level [m]:	382	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	310	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	8.67	
Soil Moisture [%]:	28.55	
Wet aboveground biomass [g m^{-2}]	8429.06	
Dry aboveground biomass [g m^{-2}]	1393.89	
Biomass water content [g m^{-2}]	7035.17	
Biomass moisture [%]	83.46	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



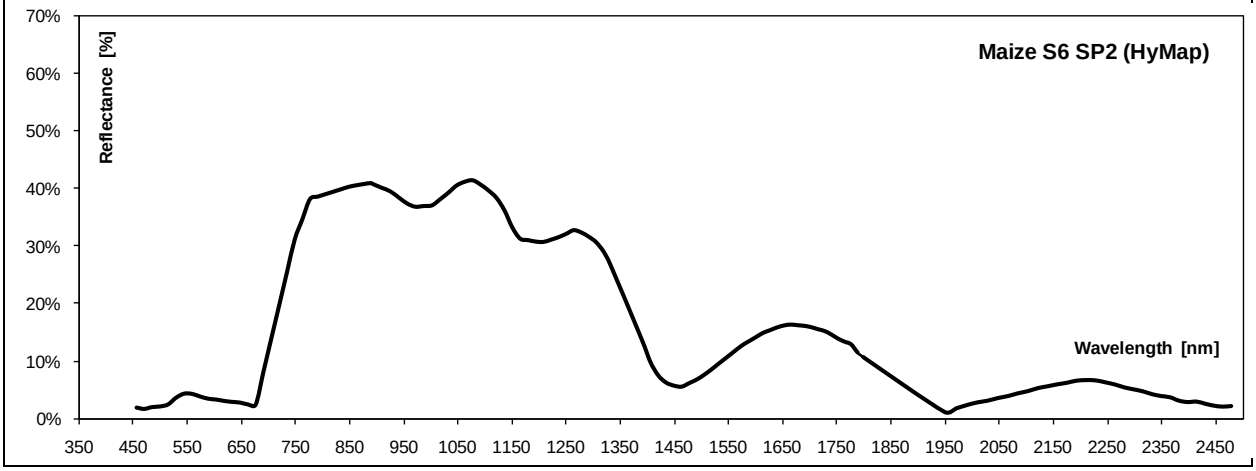
Testsite Steinbeißen – Sample Point S6SP1		
Date:	2009-07-27	
Time [CEST]:	15:32	
Easting [GK]:	^{45}54071	
Northing [GK]:	^{53}85654	
Height above Sea Level [m]:	389	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	285	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	8.00	
Soil Moisture [%]:	32.15	
Wet aboveground biomass [g m^{-2}]	7037.47	
Dry aboveground biomass [g m^{-2}]	1302.13	
Biomass water content [g m^{-2}]	5735.33	
Biomass moisture [%]	81.50	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



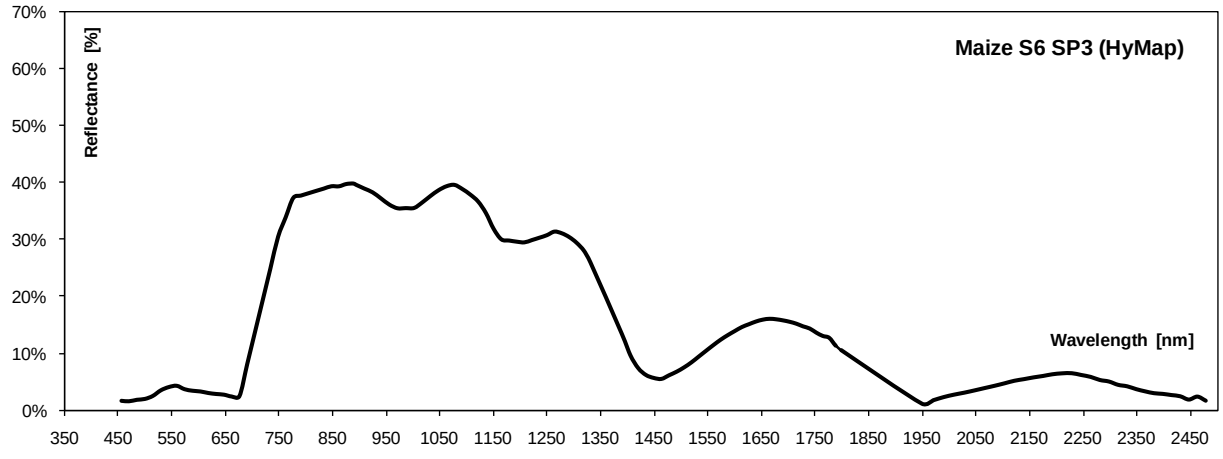
Testsite Steinbeißen – Sample Point S6SP2		
Date:	2009-07-27	
Time [CEST]:	15:46	
Easting [GK]:	^{45}54016	
Northing [GK]:	^{53}85630	
Height above Sea Level [m]:	390	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	285	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	8.67	
Soil Moisture [%]:	31.78	
Wet aboveground biomass [g m^{-2}]	7532.06	
Dry aboveground biomass [g m^{-2}]	1341.6	
Biomass water content [g m^{-2}]	6190.46	
Biomass moisture [%]	82.19	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



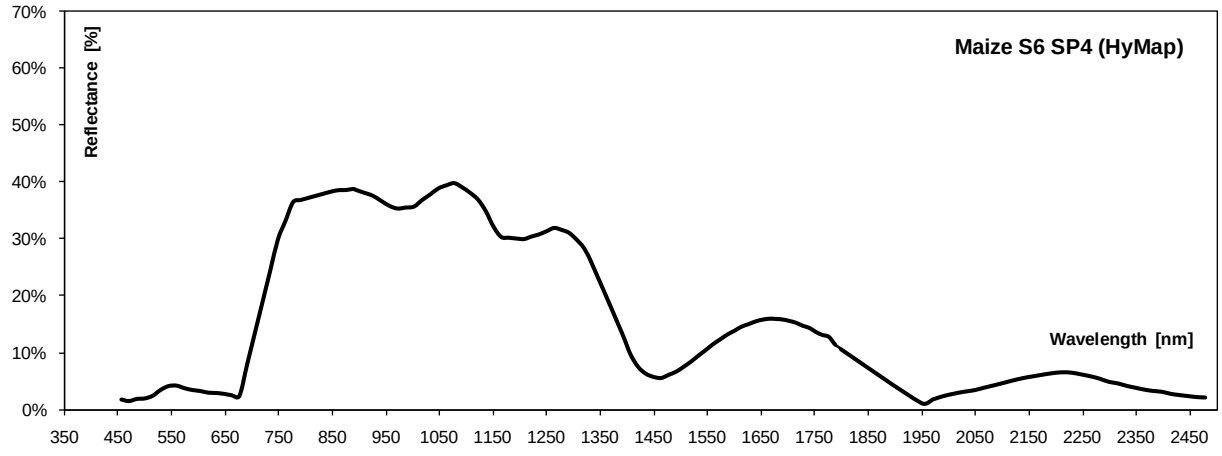
Testsite Steinbeißen – Sample Point S6SP3		
Date:	2009-07-27	
Time [CEST]:	16:08	
Easting [GK]:	^{45}54045	
Northing [GK]:	^{53}85551	
Height above Sea Level [m]:	393	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	310	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	8.00	
Soil Moisture [%]:	30.45	
Wet aboveground biomass [g m^{-2}]	8534.27	
Dry aboveground biomass [g m^{-2}]	1513.6	
Biomass water content [g m^{-2}]	7020.67	
Biomass moisture [%]	82.26	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



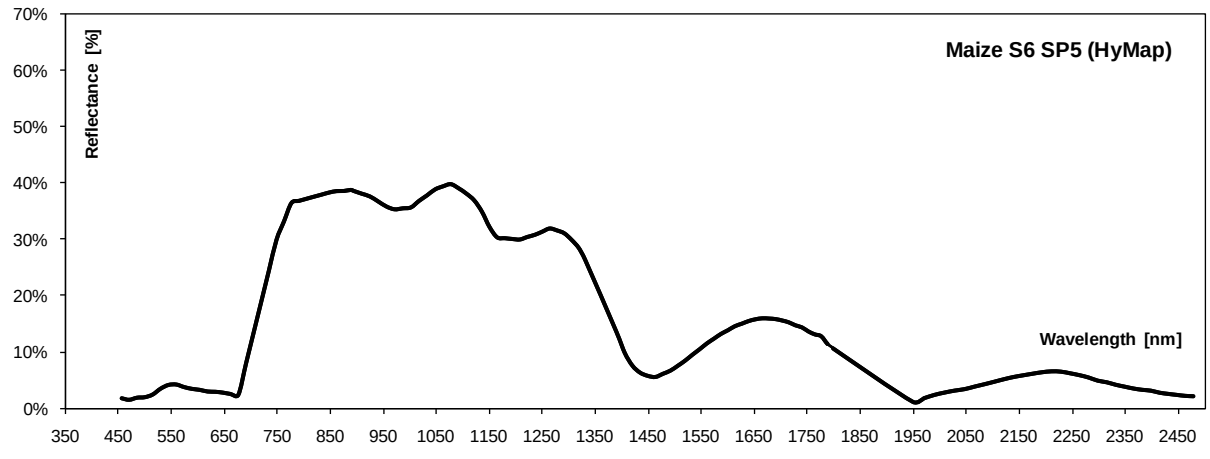
Testsite Steinbeißen – Sample Point S6SP4		
Date:	2009-07-27	
Time [CEST]:	16:21	
Easting [GK]:	^{45}54065	
Northing [GK]:	^{53}85585	
Height above Sea Level [m]:	392	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	275	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	8.67	
Soil Moisture [%]:	34.2	
Wet aboveground biomass [g m^{-2}]	9540.99	
Dry aboveground biomass [g m^{-2}]	1675.27	
Biomass water content [g m^{-2}]	7865.72	
Biomass moisture [%]	82.44	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



Testsite Steinbeißen – Sample Point S6SP5		
Date:	2009-07-27	
Time [CEST]:	16:36	
Easting [GK]:	^{45}54122	
Northing [GK]:	^{53}85583	
Height above Sea Level [m]:	392	
Landcover [IGGF Code]:	109 (Maize silage)	Sorry, no picture…
Phenology [BBCH]:	75	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	285	Vertical Photograph
Row distance [cm]:	75	
Plant density [Plt. m^{-2}]:	8.00	
Soil Moisture [%]:	30.9	
Wet aboveground biomass [g m^{-2}]	7162	
Dry aboveground biomass [g m^{-2}]	1363.2	
Biomass water content [g m^{-2}]	5798.8	
Biomass moisture [%]	80.97	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:

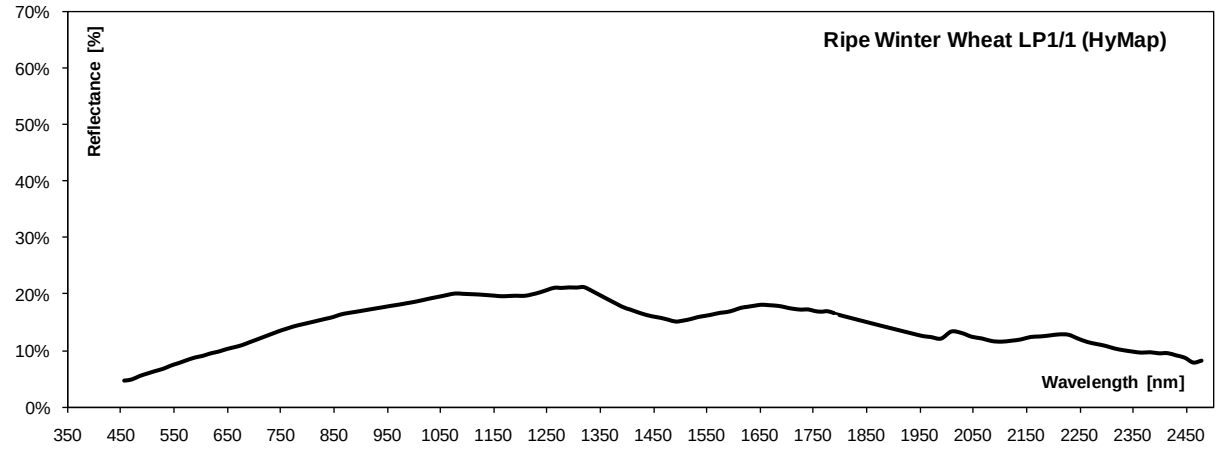


Testsite Steinbeißen – Sample Point LP1/1		
Date:	2009-07-27	
Time [CEST]:	08:55	
Easting [GK]:	^{45}53936	
Northing [GK]:	^{53}86145	
Height above Sea Level [m]:	381	
Landcover [IGGF Code]:	101 (winter wheat)	
Phenology [BBCH]:	92	
Observation:	slight slope	
Weather:	No wind; 1/8 clouds	
Canopy Height [cm]:	70	
Row distance [cm]:	10	
Plant density [Plt. m^{-2}]:	690	
Soil Moisture [%]:	31.32	
Wet aboveground biomass [g m^{-2}]	2355	
Dry aboveground biomass [g m^{-2}]	1642	
Biomass water content [g m^{-2}]	713	
Biomass moisture [%]	30.28	
Leaf Area Index	-	
LAI std. Dev.	-	

Overview photograph

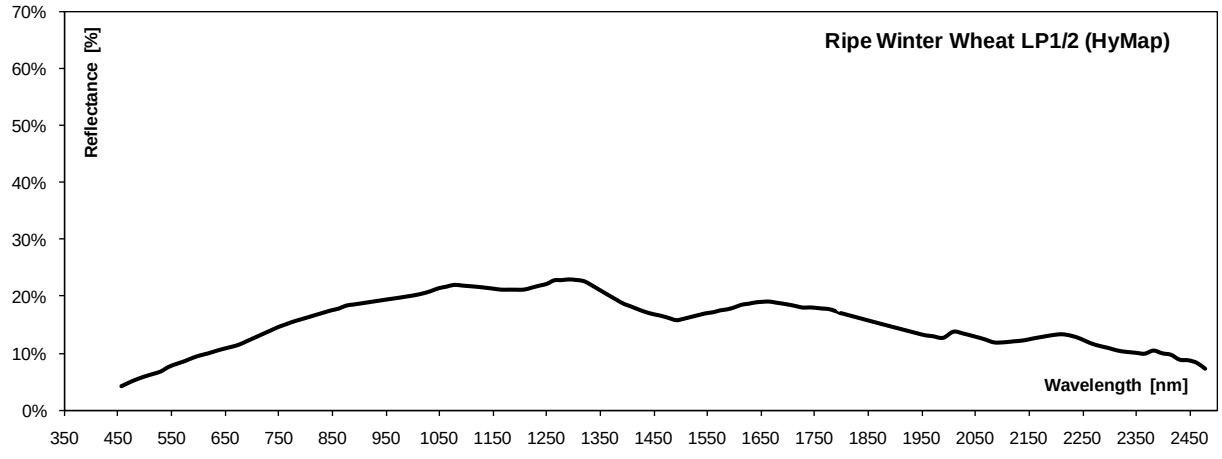
Horizontal Photograph

HyMap [Abs. Reflectance]:



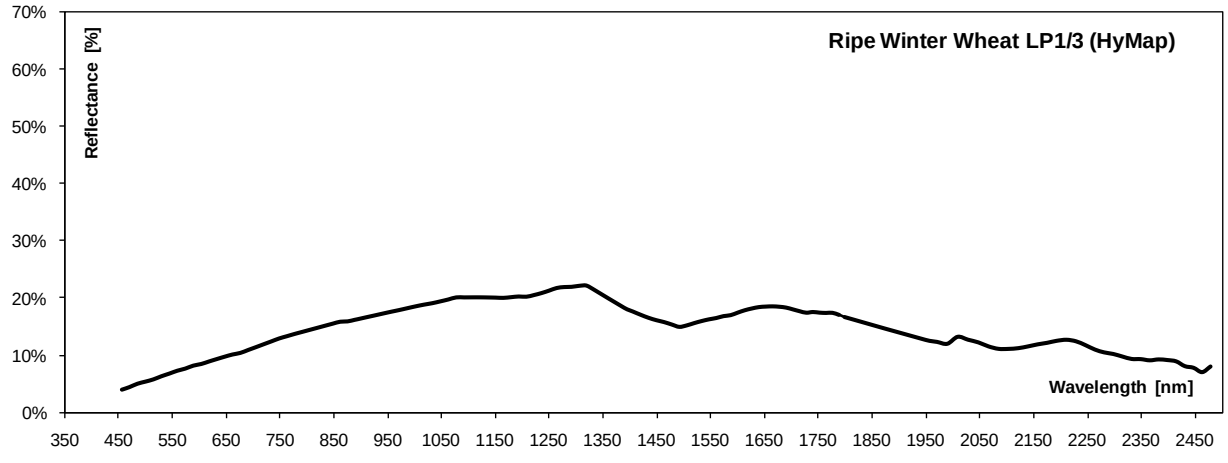
Testsite Steinbeißen – Sample Point LP1/2		
Date:	2009-07-27	
Time [CEST]:	09:20	
Easting [GK]:	^{45}53803	
Northing [GK]:	^{53}86144	
Height above Sea Level [m]:	374	
Landcover [IGGF Code]:	101 (winter wheat)	Sorry, no picture…
Phenology [BBCH]:	92	
Observation:	No special observations	
Weather:	No wind; 1/8 clouds	
Canopy Height [cm]:	77	Vertical Photograph
Row distance [cm]:	15	
Plant density [Plt. m^{-2}]:	833.33	
Soil Moisture [%]:	29.38	
Wet aboveground biomass [g m^{-2}]	2499.33	
Dry aboveground biomass [g m^{-2}]	1366.67	
Biomass water content [g m^{-2}]	1132.67	
Biomass moisture [%]	45.32	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



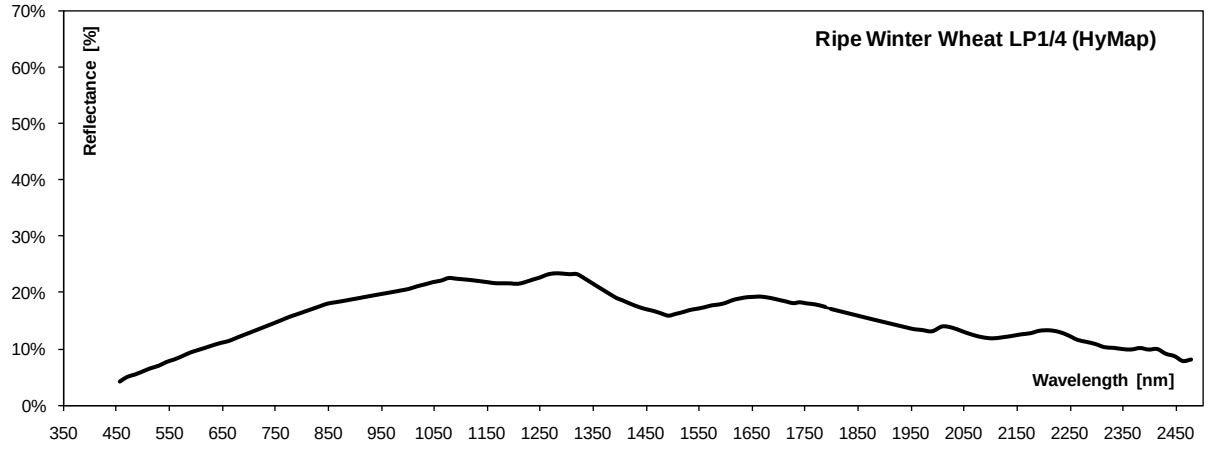
Testsite Steinbeißen – Sample Point LP1/3		
Date:	2009-07-27	
Time [CEST]:	09:35	
Easting [GK]:	^{45}53724	
Northing [GK]:	^{53}86407	
Height above Sea Level [m]:	371	
Landcover [IGGF Code]:	101 (winter wheat)	Sorry, no picture…
Phenology [BBCH]:	92	
Observation:	Standing water to the east	
Weather:	No wind; 1/8 clouds	
Canopy Height [cm]:	64	Vertical Photograph
Row distance [cm]:	12	
Plant density [Plt. m^{-2}]:	1000	
Soil Moisture [%]:	46.32	
Wet aboveground biomass [g m^{-2}]	2889.17	
Dry aboveground biomass [g m^{-2}]	1110	
Biomass water content [g m^{-2}]	1779.17	
Biomass moisture [%]	61.58	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



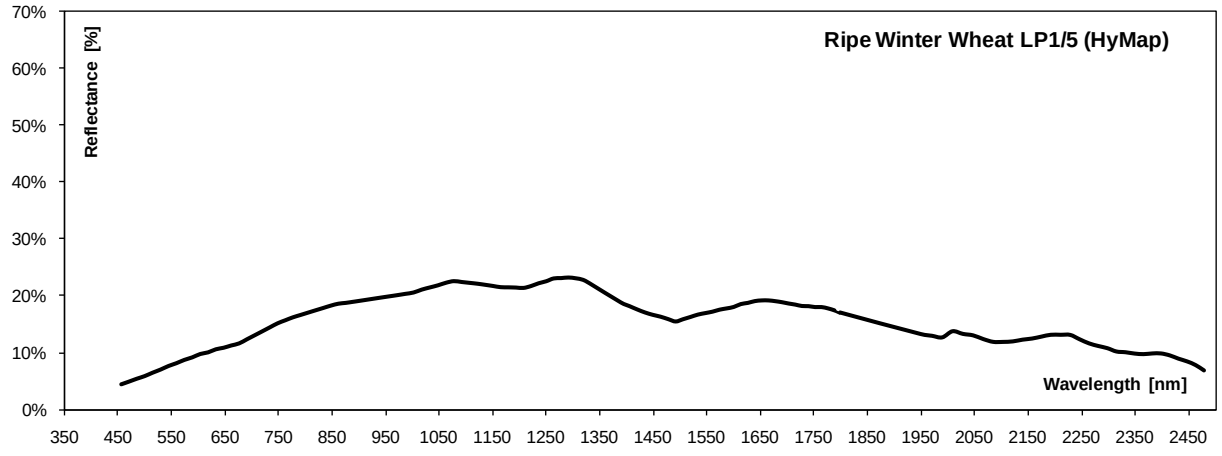
Testsite Steinbeißen – Sample Point LP1/4		
Date:	2009-07-27	
Time [CEST]:	09:52	
Easting [GK]:	^{45}53845	
Northing [GK]:	^{53}86453	
Height above Sea Level [m]:	371	
Landcover [IGGF Code]:	101 (winter wheat)	Sorry, no picture…
Phenology [BBCH]:	92	
Observation:	difficult to identify rows	
Weather:	No wind; 1/8 clouds	
Canopy Height [cm]:	73	Vertical Photograph
Row distance [cm]:	10	
Plant density [Plt. m^{-2}]:	1060	
Soil Moisture [%]:	34.38	
Wet aboveground biomass [g m^{-2}]	3913	
Dry aboveground biomass [g m^{-2}]	2448	
Biomass water content [g m^{-2}]	1465	
Biomass moisture [%]	37.44	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



Testsite Steinbeißen – Sample Point LP1/5		
Date:	2009-07-27	Sorry, no picture…
Time [CEST]:	10:10	
Easting [GK]:	^{45}53876	
Northing [GK]:	^{53}86210	
Height above Sea Level [m]:	370	
Landcover [IGGF Code]:	101 (winter wheat)	
Phenology [BBCH]:	92	
Observation:	almost the lowest place in the field	
Weather:	No wind; 1/8 clouds	
Canopy Height [cm]:	77	Vertical Photograph
Row distance [cm]:	12	
Plant density [Plt. m^{-2}]:	1108.33	
Soil Moisture [%]:	35.74	
Wet aboveground biomass [g m^{-2}]	3220.83	
Dry aboveground biomass [g m^{-2}]	1756.67	
Biomass water content [g m^{-2}]	1464.17	
Biomass moisture [%]	45.46	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:

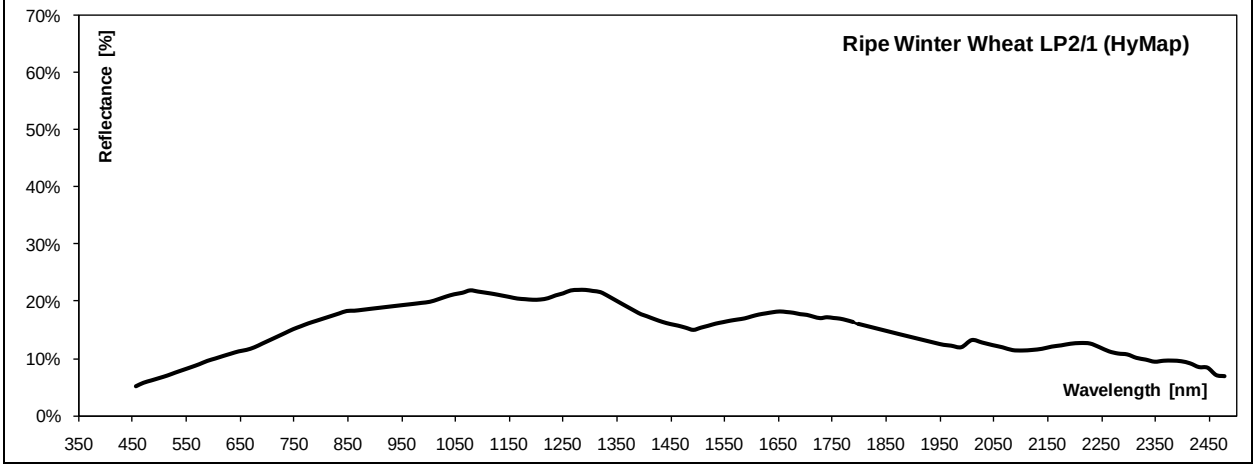


Testsite Steinbeißen – Sample Point LP2/1	
Date:	2009-07-27
Time [CEST]:	11:55
Easting [GK]:	^{45}53990
Northing [GK]:	^{53}85798
Height above Sea Level [m]:	386
Landcover [IGGF Code]:	101 (winter wheat)
Phenology [BBCH]:	93
Observation:	No special observations
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	74
Row distance [cm]:	10
Plant density [Plt. m^{-2}]:	1280
Soil Moisture [%]:	32.24
Wet aboveground biomass [g m^{-2}]	4391
Dry aboveground biomass [g m^{-2}]	2820
Biomass water content [g m^{-2}]	1571
Biomass moisture [%]	35.78
Leaf Area Index	-
LAI std. Dev.	-

Overview photograph

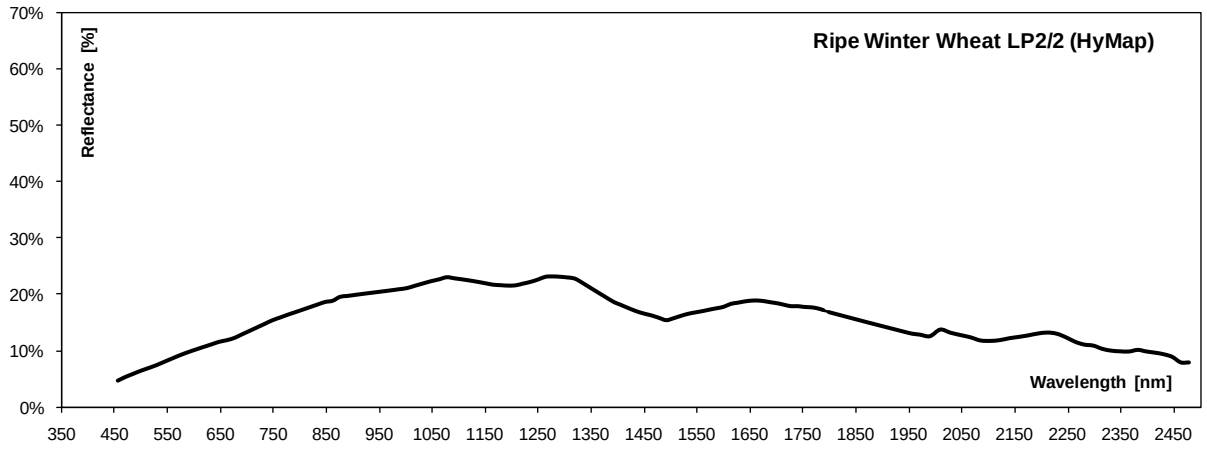
Horizontal Photograph

HyMap [Abs. Reflectance]:



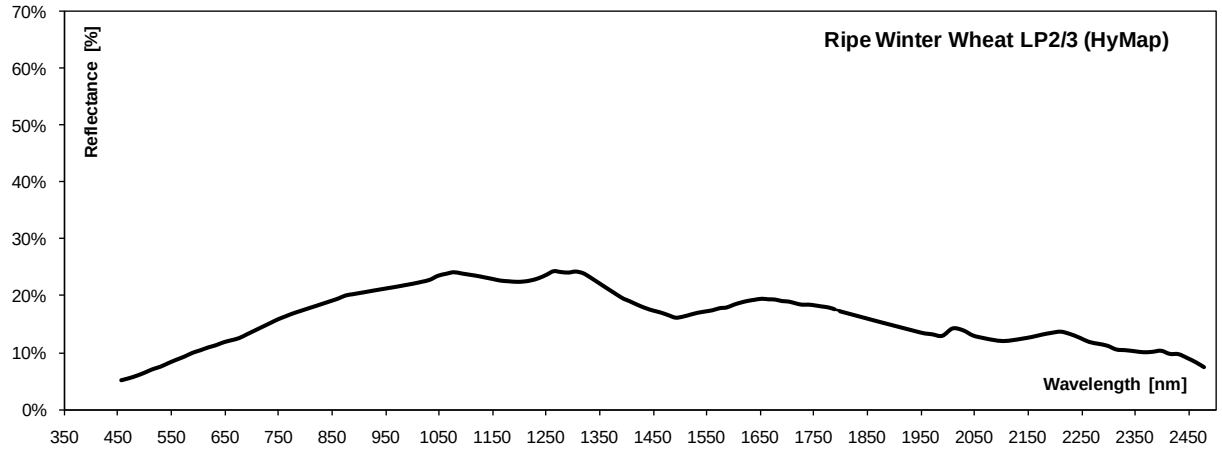
Testsite Steinbeißen – Sample Point LP2/2		
Date:	2009-07-27	Sorry, no picture…
Time [CEST]:	12:13	
Easting [GK]:	^{45}53913	
Northing [GK]:	^{53}85843	
Height above Sea Level [m]:	384	
Landcover [IGGF Code]:	101 (winter wheat)	
Phenology [BBCH]:	93	
Observation:	large amount of plants lying down around the point	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	76	Vertical Photograph
Row distance [cm]:	10	
Plant density [Plt. m^{-2}]:	1160	
Soil Moisture [%]:	29.44	
Wet aboveground biomass [g m^{-2}]	3807	
Dry aboveground biomass [g m^{-2}]	2466	
Biomass water content [g m^{-2}]	1341	
Biomass moisture [%]	35.22	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



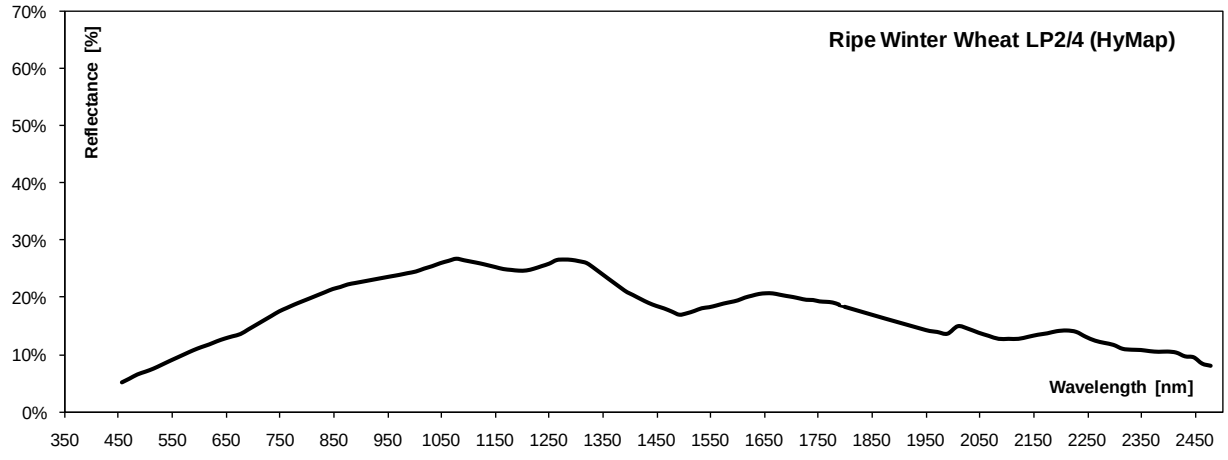
Testsite Steinbeißen – Sample Point LP2/3		
Date:	2009-07-27	
Time [CEST]:	12:26	
Easting [GK]:	^{45}53923	
Northing [GK]:	^{53}85954	
Height above Sea Level [m]:	381	
Landcover [IGGF Code]:	101 (winter wheat)	Sorry, no picture…
Phenology [BBCH]:	92	
Observation:	plants lying down around the point	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	76	Vertical Photograph
Row distance [cm]:	13	
Plant density [Plt. m^{-2}]:	953.85	
Soil Moisture [%]:	31.62	
Wet aboveground biomass [g m^{-2}]	3197.69	
Dry aboveground biomass [g m^{-2}]	1920	
Biomass water content [g m^{-2}]	1277.69	
Biomass moisture [%]	39.96	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



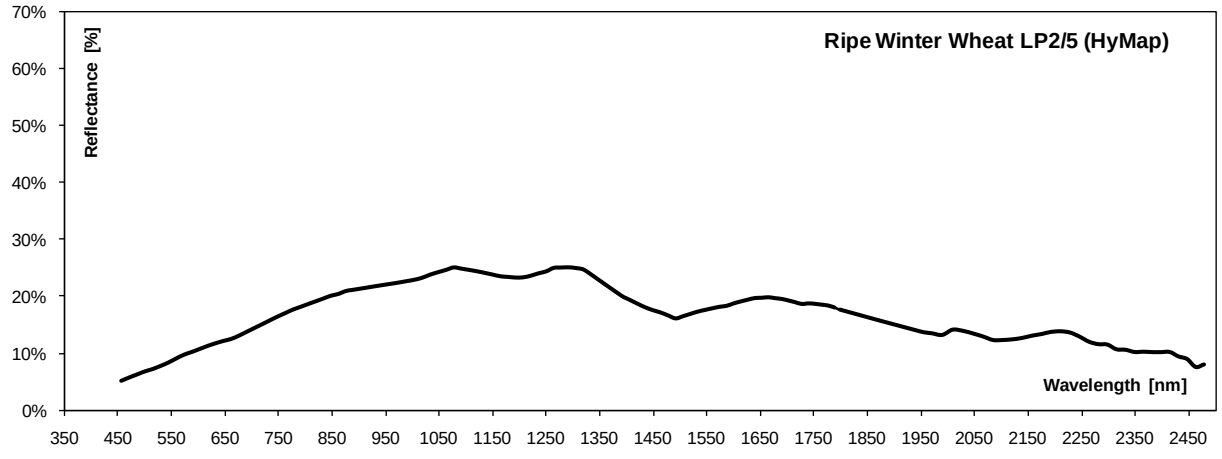
Testsite Steinbeißen – Sample Point LP2/4		
Date:	2009-07-27	Sorry, no picture…
Time [CEST]:	12:40	
Easting [GK]:	^{45}53847	
Northing [GK]:	^{53}86015	
Height above Sea Level [m]:	380	
Landcover [IGGF Code]:	101 (winter wheat)	
Phenology [BBCH]:	92	
Observation:	a few plats lying down around the point	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	78	Vertical Photograph
Row distance [cm]:	12	
Plant density [Plt. m^{-2}]:	1050	
Soil Moisture [%]:	33.48	
Wet aboveground biomass [g m^{-2}]	3180.83	
Dry aboveground biomass [g m^{-2}]	1935	
Biomass water content [g m^{-2}]	1245.83	
Biomass moisture [%]	39.17	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



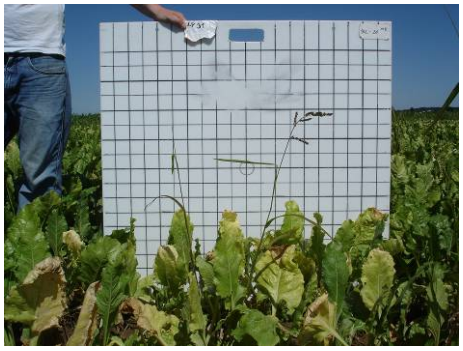
Testsite Steinbeißen – Sample Point LP2/5		
Date:	2009-07-27	
Time [CEST]:	12:50	
Easting [GK]:	^{45}53900	
Northing [GK]:	^{53}86022	
Height above Sea Level [m]:	381	
Landcover [IGGF Code]:	101 (winter wheat)	Sorry, no picture…
Phenology [BBCH]:	92	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	78	Vertical Photograph
Row distance [cm]:	11	
Plant density [Plt. m^{-2}]:	1009.09	
Soil Moisture [%]:	31.4	
Wet aboveground biomass [g m^{-2}]	3484.55	
Dry aboveground biomass [g m^{-2}]	2194.55	
Biomass water content [g m^{-2}]	1290	
Biomass moisture [%]	37.02	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



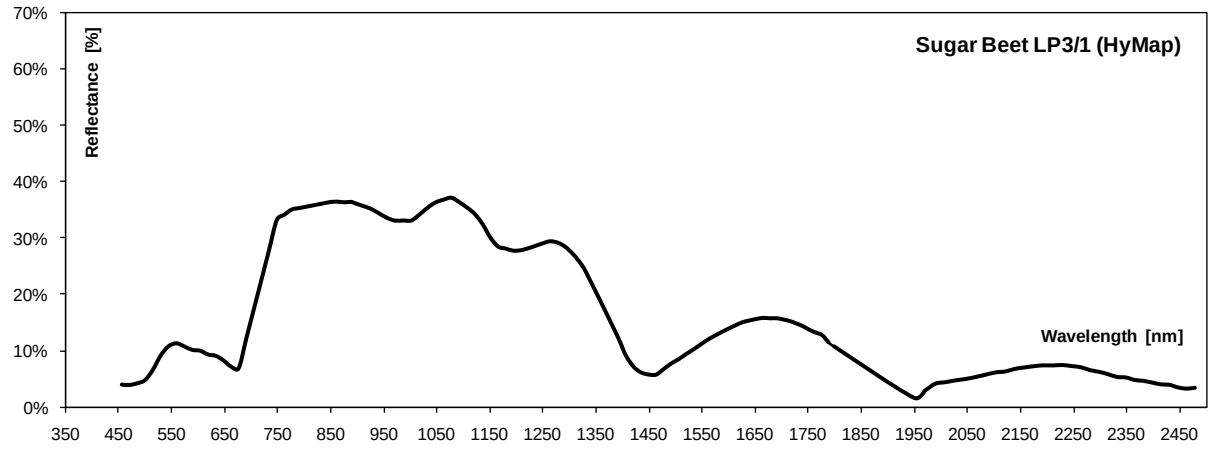
Testsite Steinbeißen – Sample Point LP3/1	
Date:	2009-07-27
Time [CEST]:	14:53
Easting [GK]:	^{45}53571
Northing [GK]:	^{53}86236
Height above Sea Level [m]:	373
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	93 (52)
Observation:	Very wet because of backwater; plants cracked
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	45
Row distance [cm]:	44
Plant density [Plt. m^{-2}]:	11.36
Soil Moisture [%]:	47.08
Wet aboveground biomass [g m^{-2}]	4488.86
Dry aboveground biomass [g m^{-2}]	630.91
Biomass water content [g m^{-2}]	3857.95
Biomass moisture [%]	85.95
Leaf Area Index	-
LAI std. Dev.	-

Overview photograph, drainage



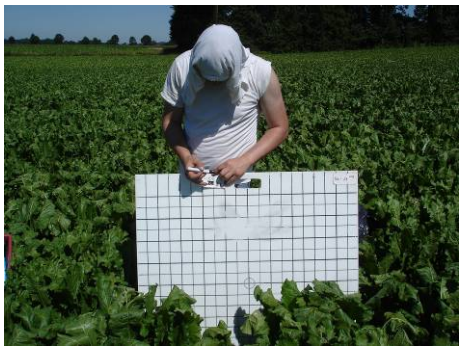
Horizontal Photograph

HyMap [Abs. Reflectance]:



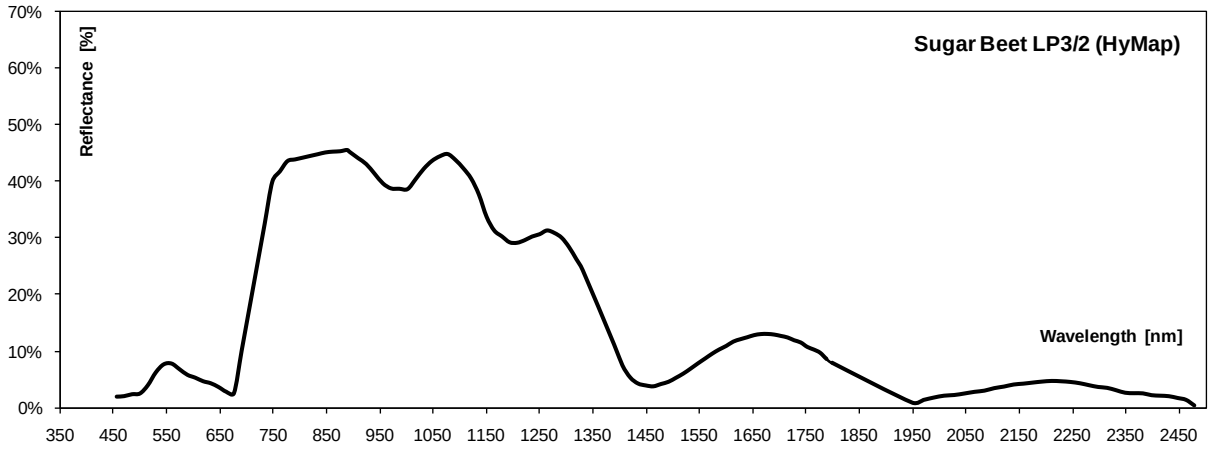
Testsite Steinbeißen – Sample Point LP3/2	
Date:	2009-07-27
Time [CEST]:	15:10
Easting [GK]:	^{45}53497
Northing [GK]:	^{53}86222
Height above Sea Level [m]:	371
Landcover [IGGF Code]:	304 (sugar beet)
Phenology [BBCH]:	52
Observation:	No special observations
Weather:	No wind; 0/8 clouds
Canopy Height [cm]:	42
Row distance [cm]:	43
Plant density [Plt. m^{-2}]:	12.79
Soil Moisture [%]:	42.5
Wet aboveground biomass [g m^{-2}]	5393.26
Dry aboveground biomass [g m^{-2}]	564.19
Biomass water content [g m^{-2}]	4829.07
Biomass moisture [%]	89.54
Leaf Area Index	-
LAI std. Dev.	-

Vertical Photograph



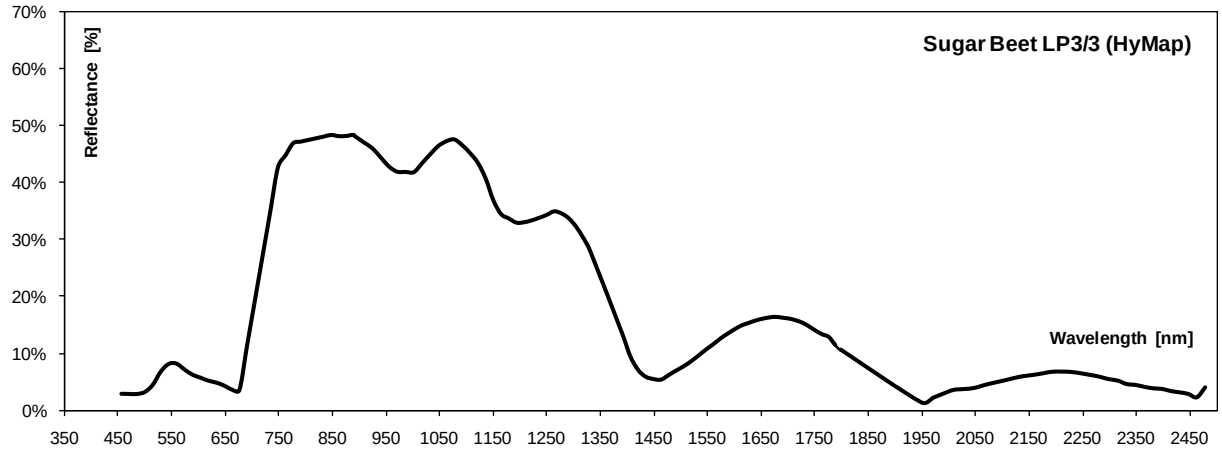
Horizontal Photograph

HyMap [Abs. Reflectance]:



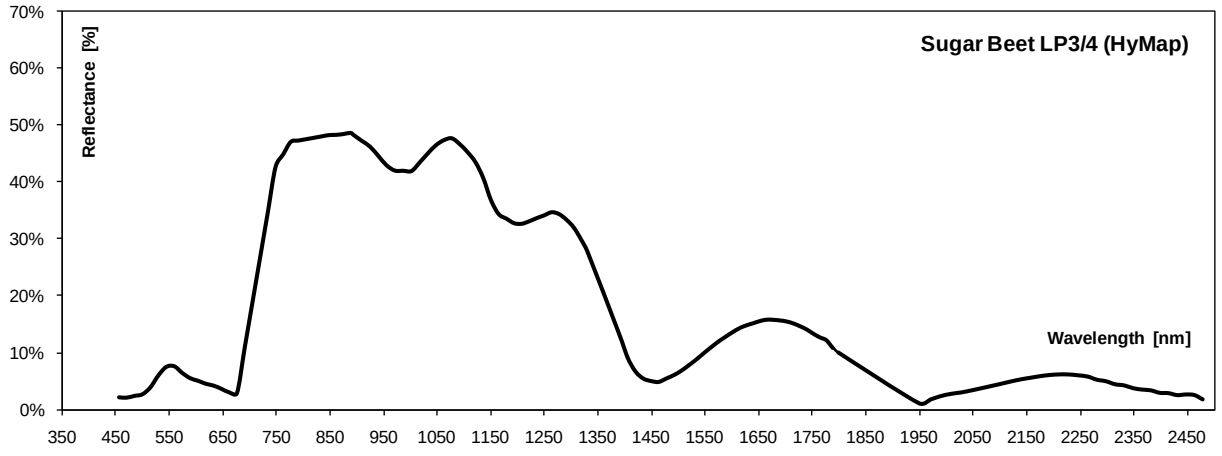
Testsite Steinbeißen – Sample Point LP3/3		
Date:	2009-07-27	
Time [CEST]:	15:22	
Easting [GK]:	^{45}53559	
Northing [GK]:	^{53}86125	
Height above Sea Level [m]:	373	
Landcover [IGGF Code]:	304 (sugar beet)	Sorry, no picture…
Phenology [BBCH]:	52	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	56	Vertical Photograph
Row distance [cm]:	41	
Plant density [Plt. m^{-2}]:	9.76	
Soil Moisture [%]:	34.68	
Wet aboveground biomass [g m^{-2}]	8550	
Dry aboveground biomass [g m^{-2}]	820	
Biomass water content [g m^{-2}]	7730	
Biomass moisture [%]	90.41	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



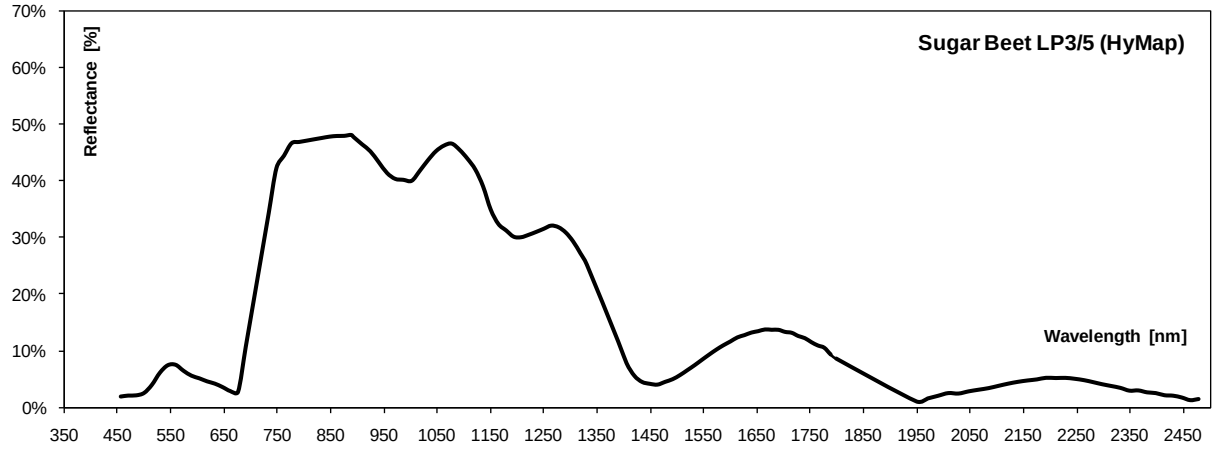
Testsite Steinbeißen – Sample Point LP3/4		
Date:	2009-07-27	Sorry, no picture…
Time [CEST]:	15:33	
Easting [GK]:	^{45}53566	
Northing [GK]:	^{53}86018	
Height above Sea Level [m]:	377	
Landcover [IGGF Code]:	304 (sugar beet)	
Phenology [BBCH]:	52	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	57	Vertical Photograph
Row distance [cm]:	57	
Plant density [Plt. m^{-2}]:	7.89	
Soil Moisture [%]:	30.28	
Wet aboveground biomass [g m^{-2}]	4691.4	
Dry aboveground biomass [g m^{-2}]	486.67	
Biomass water content [g m^{-2}]	4204.74	
Biomass moisture [%]	89.63	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



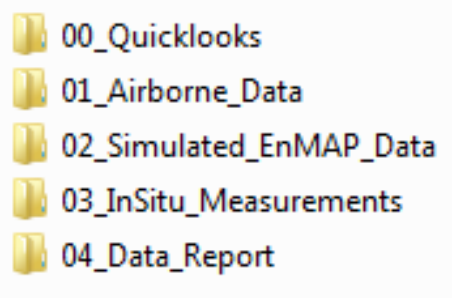
Testsite Steinbeißen – Sample Point LP3/5		
Date:	2009-07-27	
Time [CEST]:	15:43	
Easting [GK]:	^{45}53652	
Northing [GK]:	^{53}85996	
Height above Sea Level [m]:	379	
Landcover [IGGF Code]:	304 (sugar beet)	Sorry, no picture…
Phenology [BBCH]:	52	
Observation:	No special observations	
Weather:	No wind; 0/8 clouds	
Canopy Height [cm]:	54	Vertical Photograph
Row distance [cm]:	47	
Plant density [Plt. m^{-2}]:	12.77	
Soil Moisture [%]:	29.96	
Wet aboveground biomass [g m^{-2}]	8339.36	
Dry aboveground biomass [g m^{-2}]	851.91	
Biomass water content [g m^{-2}]	7487.45	
Biomass moisture [%]	89.78	
Leaf Area Index	-	Horizontal Photograph
LAI std. Dev.	-	

HyMap [Abs. Reflectance]:



10.11 List of available datasets

The provided data (size: 3,37 GB) are structured into five folders:



The folder **"00_Quicklooks"** (size: 68 MB) contains the following data:

Filename	Extension	Format	Size	Content
090727_Neusling_Quicklook	*.tif	GeoTiff-File for direct import e.g. into ESRI ArcGIS	31,5 MB	True-Color representation of the Neusling HyMap Flight strip
090727_Neusling_Quicklook	*.rrd	ESRI ArcGIS Pyramid-layers file	3 MB	Pyramid-Layers for 090727_Neusling_Quicklook.tif
090727_Neusling_Quicklook	*.aux	ESRI ArcGIS Statistics file	340 KB	Statistics for 090727_Neusling_Quicklook.tif
090727_Neusling	*.kmz	Keyhole Markup Language Zipped	13 KB	Placemark file containing the contours of the Neusling HyMap flight strip for display e.g. in Google Earth
090727_Steinbeissen_Quicklook	*.tif	GeoTiff-File for direct import e.g. into ESRI ArcGIS	31,7 MB	True-Color representation of the Steinbeissen HyMap Flight strip
090727_ Steinbeissen_Quicklook	*.rrd	ESRI ArcGIS Pyramid-layers file	3 MB	Pyramid-Layers for 090727_Steinbeissen_Quicklook.tif
090727_ Steinbeissen_Quicklook	*.aux	ESRI ArcGIS Statistics file	389 KB	Statistics for 090727_Steinbeissen_Quicklook.tif
090727_ Steinbeissen	*.kmz	Keyhole Markup language Zipped	14 KB	Placemark file containing the contours of the Steinbeissen HyMap flight strip for display e.g. in Google Earth

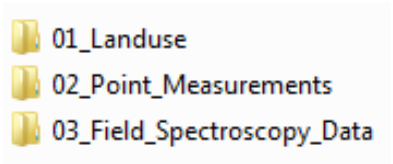
The folder **“01_Airborne_Data”** (size: 3,2 GB) contains the following data:

Filename	Extension	Format	Size	Content
090727_Neusling_rad_geo_atm	*.bsq	ENVI Band sequential Image data	1,24 GB	Radiometrically, atmospherically and geometrically corrected airborne hyperspectral data of the Neusling area (BOA Reflectance)
090727_Neusling_rad_geo_atm.bsq	*.enp	ENVI pyramids file	412 MB	Image Pyramids for “090727_Neusling_rad_geo_atm.bsq”
090727_Neusling_rad_geo_atm	*.hdr	ENVI Header-File	6 KB	Image metadata for “090727_Neusling_rad_geo_atm.bsq”
090727_Neusling_rad_geo_atm	*.log	Log-file	6 KB	Parameters used for atmospheric correction of “090727_Neusling_rad_geo_atm.bsq”
090727_Steinbeissen_rad_geo_atm	*.bsq	ENVI Band sequential Image data	1,28 GB	Radiometrically, atmospherically and geometrically corrected airborne hyperspectral data of the Steinbeissen area
090727_Steinbeissen_rad_geo_atm.bsq	*.enp	ENVI pyramids file	426 MB	Image Pyramids for “090727_Steinbeissen_rad_geo_atm.bsq”
090727_Steinbeissen_rad_geo_atm	*.hdr	ENVI Header-File	6 KB	Image metadata for “090727_Steinbeissen_rad_geo_atm.bsq”
090727_Steinbeissen_rad_geo_atm	*.log	Log-file	6 KB	Parameters used for atmospheric correction of “090727_Steinbeissen_rad_geo_atm.bsq”

The folder “**02_Simulated_EnMAP_Data**” (size: 19 MB) contains the following data:

Filename	Extension	Format	Size	Content
090727_Neusling_simulated_EnMAP	*.bsq	ENVI Band sequential Image data	6,3 MB	EeteS-simulated EnMAP data of the Neusling area
090727_Neusling_simulated_EnMAP.bsq	*.enp	ENVI pyramids file	6,6 MB	Image Pyramids for “090727_Neusling_simulated_EnMAP.bsq”
090727_Neusling_simulated_EnMAP	*.hdr	ENVI Header-File	3 KB	Image metadata for “090727_Neusling_simulated_EnMAP.bsq”

The folder **“03_InSitu_Measurements”** (size: 55 MB) contains three sub-folders:



The folder **“03_InSitu_Measurements/01_Landuse”** (size: 2 MB) contains the following data:

Filename	Extension	Format	Size	Content
LanduseMap_Neusling_2009_07	*.cpg	ESRI ArcGIS Code Page conversion file	1 KB	specifies the code page for identifying the character set to be used
LanduseMap_Neusling_2009_07*	*.dbf	ESRI ArcGIS dBASE table	454 KB	stores the attribute information of features
LanduseMap_Neusling_2009_07	*.prj	ESRI ArcGIS projection file	1 KB	stores the coordinate system information
LanduseMap_Neusling_2009_07	*.sbn	ESRI ArcGIS spatial index file 1	15 KB	stores the spatial index of the features
LanduseMap_Neusling_2009_07	*.sbx	ESRI ArcGIS spatial index file 2	2 KB	stores the spatial index of the features
LanduseMap_Neusling_2009_07	*.shp	ESRI ArcGIS shapefile	618 KB	Polygon feature geometry of the Landuse, mapped for July 2009 in the Neusling Test Area
LanduseMap_Neusling_2009_07.shp	*.xml	ESRI ArcGIS metadata file	2 KB	stores information about the shapefile
LanduseMap_Neusling_2009_07	*.shx	ESRI ArcGIS index file	12 KB	stores the index of the feature geometry
LanduseMap_Steinbeissen_2009_07	*.cpg	ESRI ArcGIS Code Page conversion file	1 KB	specifies the code page for identifying the character set to be used
LanduseMap_Steinbeissen_2009_07+	*.dbf	ESRI ArcGIS dBASE table	472 KB	stores the attribute information of features
LanduseMap_Steinbeissen_2009_07	*.prj	ESRI ArcGIS projection file	1 KB	stores the coordinate system information
LanduseMap_Steinbeissen_2009_07	*.sbn	ESRI ArcGIS spatial index file 1	15 KB	stores the spatial index of the features
LanduseMap_Steinbeissen_2009_07	*.sbx	ESRI ArcGIS spatial index file 2	2 KB	stores the spatial index of the features
LanduseMap_Steinbeissen_2009_07	*.shp	ESRI ArcGIS shapefile	641 KB	Polygon feature geometry of the Landuse, mapped for July 2009 in the Steinbeissen Test Area
LanduseMap_Steinbeissen_2009_07.shp	*.xml	ESRI ArcGIS metadata file	1 KB	stores information about the shapefile
LanduseMap_Steinbeissen_2009_07	*.shx	ESRI ArcGIS index file	13 KB	stores the index of the feature geometry

*The attribute table of “LanduseMap_Neusling_2009_07” contains the following information:

FID	= Feature ID: Unique identification number for individual features
Shape	= Polygon
OBJECTID	= Unique object identifier
Shape_Leng	= shape circumference [m]
Shape_Area	= shape area [m²]
Lanu-Code	= IGGF- Landcover code

+The attribute table of “LanduseMap_Steinbeissen_2009_07” contains the following information:

FID	= Feature ID: Unique identification number for individual features
Shape	= Polygon
OBJECTID	= Unique object identifier
Steinbei_1	= Comment field
Landuse__1	= IGGF- Landcover code
Landuse__2	= Landuse

Comment	= Comment field
Landuse	= Landuse
Latin_Name	= Latin Name of some crops
Cover_Type	= Superordinate land cover type
Cover_Cat	= Superordinate land cover category

Landuse__3	= Latin Name of some crops
Landuse__4	= Superordinate land cover category
Shape_Leng	= shape circumference [m]
Shape_Area	= shape area [m²]
LandType	= Superordinate land cover type

The folder **"03_InSitu_Measurements/02_Point_Measurements"** (size: 600 KB) contains the following data:

Filename	Extension	Format	Size	Content
InSitu_Measurements_2009_07_27	*.cpg	ESRI ArcGIS Code Page conversion file	1 KB	specifies the code page for identifying the character set to be used
InSitu_Measurements_2009_07_27*	*.dbf	ESRI ArcGIS dBASE table	454 KB	stores the attribute information of features
InSitu_Measurements_2009_07_27	*.prj	ESRI ArcGIS projection file	1 KB	stores the coordinate system information
InSitu_Measurements_2009_07_27	*.sbn	ESRI ArcGIS spatial index file 1	15 KB	stores the spatial index of the features
InSitu_Measurements_2009_07_27	*.sbx	ESRI ArcGIS spatial index file 2	2 KB	stores the spatial index of the features
InSitu_Measurements_2009_07_27	*.shp	ESRI ArcGIS shapefile	618 KB	Point feature geometry containing the in-situ measurements collected on the 27th of July 2009 in the Neusling Test Area
InSitu_Measurements_2009_07_27.shp	*.xml	ESRI ArcGIS metadata file	2 KB	stores information about the shapefile
InSitu_Measurements_2009_07_27	*.shx	ESRI ArcGIS index file	12 KB	stores the index of the feature geometry

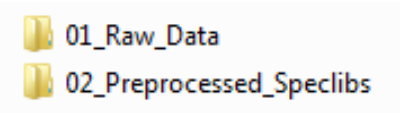
*The attribute table contains the following information:

FID	= Feature ID: Unique identification number for individual features
Shape	= Point
Easting__G	= Easting in Gauß-Krüger coordinates (Zone 4)
Northing__	= Northing in Gauß-Krüger coordinates (Zone 4)
Elevation_	= Elevation measured with GPS [m above sea level], -9999 = no data
Sample_poi	= Name of sample point
Team	= Responsible ground measuring team
Year	= Year when the measurement was conducted
Month	= Month when the measurement was conducted
Day	= Day when the measurement was conducted
Hour__CEST	= Hour when the measurement was conducted [Central European Summer Time]
Minute	= Minute when the measurement was conducted
IGGF_Code	= IGGF- Landcover code
Land_cover	= Land cover at the sample point
Phenology_	= Observation of crop phenology [BBCH]

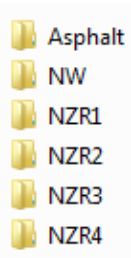
Biomass_dr	= Dry aboveground biomass [g/m²]
Biomass__1	= Absolute water content in aboveground biomass [g/m²]
UTM_East	= Easting in UTM coordinates (Zone 32 north)
UTM_Notrh	= Northing in UTM coordinates (Zone 32 north)
Gebiet	= Identifier of sample region (Neusling or Steinbeissen)

Observatio	= Additional observations / comments
Weather	= Cloud and wind observations during the measurements
Canopy_hei	= Canopy height [cm], -9999 = no data
Row_distan	= Row distance of the sowing tracks [cm], -9999 = no data
Plant_dens	= Plant density [plants per m²]
LAI	= Leaf Area Index, -9999 = no data
LAI_std_de	= Standard deviation of LAI measurements for the respective sample point
Photograph	= Code used for identification of digital photographs of the sample point
Avg_soil_m	= Average soil moisture [%]
Std_dev_of	= Standard deviation of soil moisture measurements for the respective sample point
Biomass_wa	= Relative water content in aboveground biomass [%]
Biomass_we	= Fresh aboveground biomass [g/m²]

The folder **“03_InSitu_Measurements/03_Field_Spectroscopy_Data”** (size: 52 MB) contains two subfolders:



The folder **“03_InSitu_Measurements/03_Field_Spectroscopy_Data/01_Raw_Data”** (size: 8 MB) contains six subfolders:



These subfolders contain the raw spectral in-situ measurements of different surfaces [Asphalt = Asphalt, NW = Neusling Wheat (5 sample points from one test field), NZR = Neusling ZuckerRübe/Sugar Beet (5 sample points each from 4 test fields)]. All data are in raw ASD (Analytical Spectral Devices) binary format. This data can be read using the “ASD ViewSpecPro” Software.

The folder **“03_InSitu_Measurements/03_Field_Spectroscopy_Data/02_Preprocessed_Speclibs”** (size: 45 MB) contains the following data:

Filename	Extension	Format	Size	Content
090727_ASD_Measurements	*.xls	Microsoft Excel Spreadsheet	44,6 MB	ASCII-imported, splice-corrected, water vapor removed spectra

The folder **“04_Data_Report”** (size: 31 MB) contains the following data

Filename	Extension	Format	Size	Content
EnMAP_TechnicalReport_Neusling_2009	*.pdf	Adobe Portable Document Format	30,5 MB	Technical report describing the 2009 HyMap campaign in Neusling and Steinbeissen
EnMAP_TechnicalReport_Neusling_2009_Data_List	*.pdf	Adobe Portable Document Format	914 KB	This data list