A novel approach for the categorization of cropland and grassland based on multi-seasonal high and medium resolution satellite imagery

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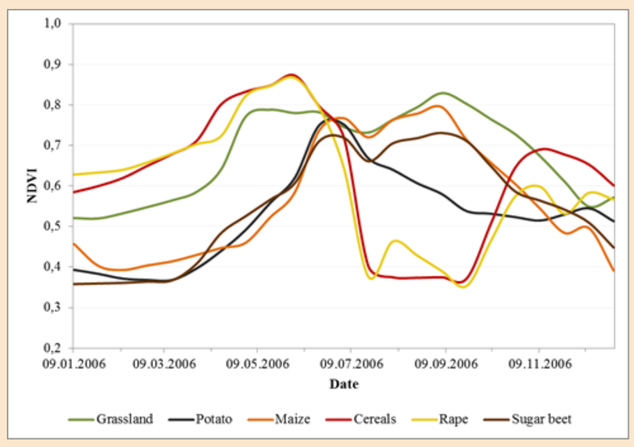
Introduction

- The implementation of effective and sustainable cultivation procedures is a key element in the framework of the European Community agricultural production;
- Political, economic and environmental factors influence the cultivation strategies directly and indirectly, and therewith strongly determine the condition and transformation of the cultivated and natural landscape;
- A frequent and area-wide monitoring of cropland and grassland is required to assess the actual status, identify basic trends, and mitigate major threats with respect to the agricultural production and its impact on the cultural and natural landscape;
- Currently available EO-based land-use/land-cover (LULC) datasets (e.g., national topographic data, CORINE Land Cover, etc.) generally exhibit poor spatial and semantic resolution both for cropland and grassland;
- To overcome this limitation, we present an operational and application-oriented approach aimed at improving the level of thematic/geometric detail for given LULC datasets;
- A novel system is proposed for the categorization of agricultural cropland and grassland combining multi-resolution EO data with ancillary geo-information available from currently existing databases;
- Multi-seasonal high (HR) and medium resolution (MR) satellite imagery is used for determining crop types as well as differentiating between cropland and grassland, respectively.

Seasonal Characteristics of Grassland and Crops

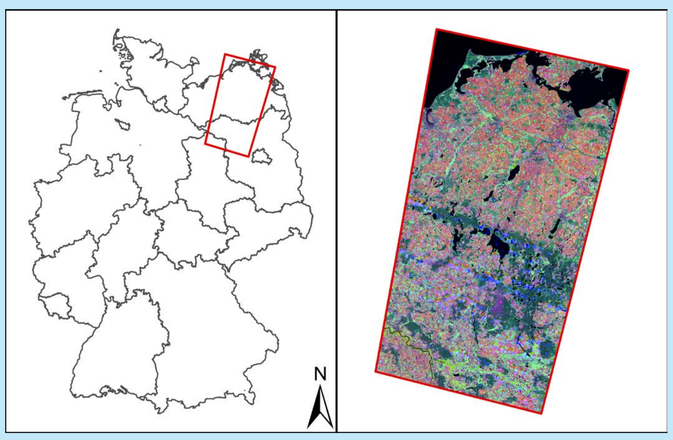
- The spectral characteristics of grassland and crops show significant variations throughout the vegetation period, but their spectra are quite similar for at least some points in time;
- Cropland shows highly variable seasonal characteristics;
- Grassland generally experiences a more continuous seasonal development;
- Due to almost uncertain intra-class variabilities particular sub-classes might show similar behaviours;
- Main drivers for the different seasonal behaviours are the local climate at the given geographical region, weather conditions during the vegetation period, sowing dates, cultivation cycles and forms, and the harvesting times (cropland) or mowing dates (grassland), respectively.



Variation of the Normalized Difference Vegetation Index (NDVI) throughout the vegetation period for semi-natural grassland and different crop types derived from data of the MODIS sensor.

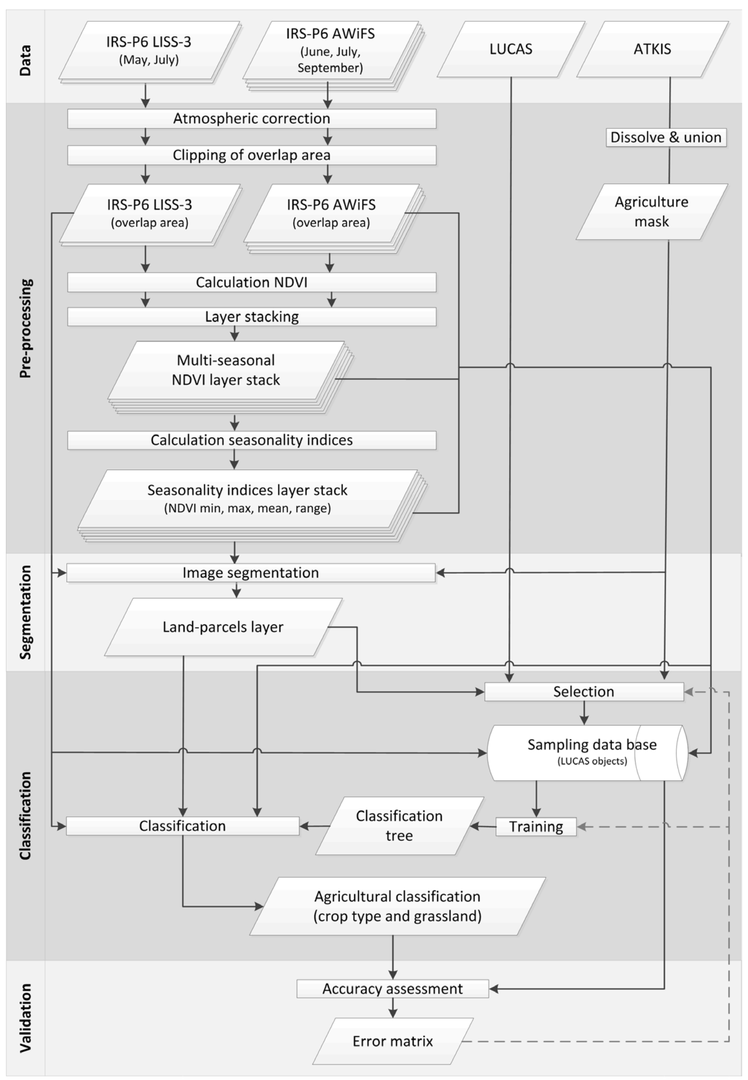
Multi-scale Analysis of Seasonal Time Series Data

- Main challenge: the collection of a cloud-free data base covering key dates and seasons with enough spatial detail to assure an accurate analysis at field-parcel level;
- Basic idea: combining the interpretation of multi-seasonal high and medium resolution optical data;
- Test area: an agricultural region in Mecklenburg Western Pomerania (MV) and Brandenburg (BB), Germany dominated by agriculture, woodland, settlement and water bodies;

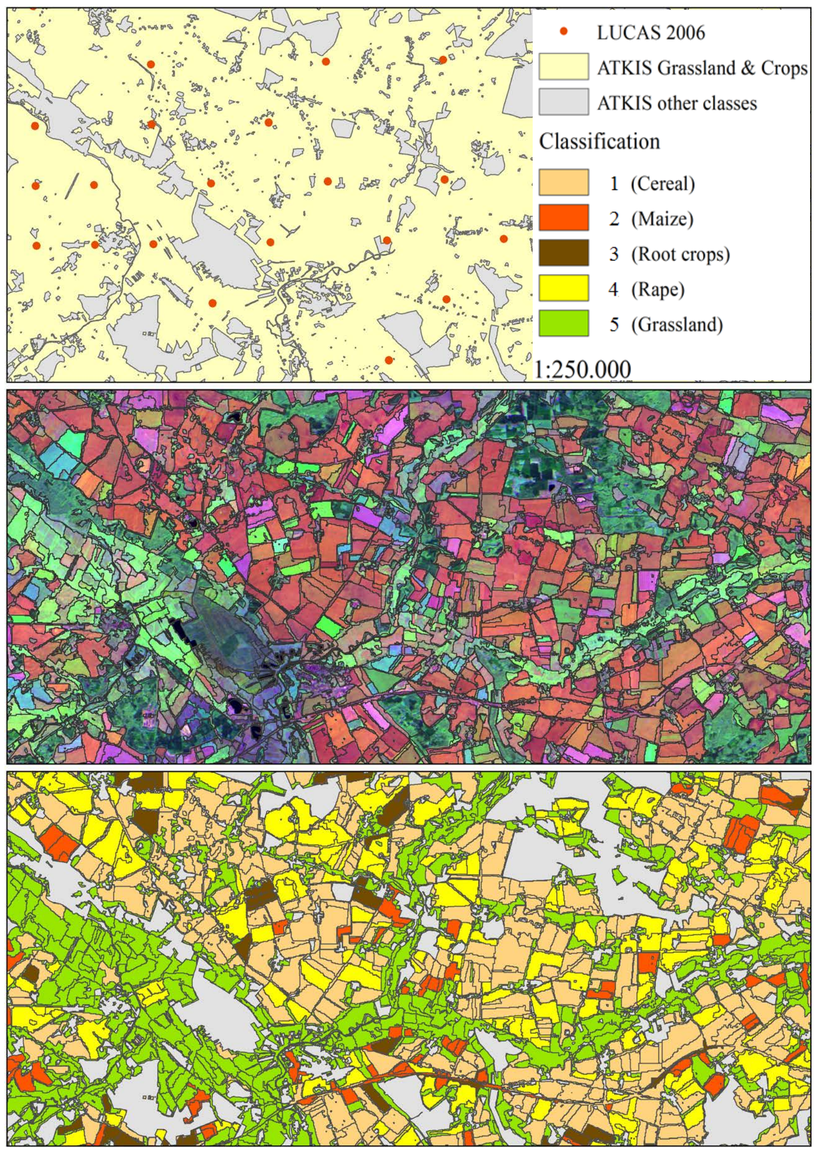


Left: Test area within Germany, Right: Multi-seasonal EO data set of test area.

- 2 HR IRS-P6 LISS-3 images (23.5m, 4 bands; 05.05.06, 17.07.06) are used to properly delineate different land parcels in region of interest by means of segmentation;
- 3 MR IRS-P6 AWiFS scenes (56m, 4 bands; 13.06.06, 17.07.06, 12.09.06) are used together with HR images to derive a series of seasonality indices (namely, seasonal minimum, seasonal maximum, seasonal mean and the range between minimum and maximum);
- A mask derived from vector data of the German Authoritative Topographic-Cartographic Information System (ATKIS) is used to focus on crop- and grassland;
- Thematic point data of the Land Use/Cover Area frame statistical Survey (LUCAS) 2006 are employed for training and validation purposes (overall 1529 points, 50% used for training and 50% used for validation);
- The C5.0 classifier was employed to categorize main crop types and grassland;
- C5.0 algorithm automatically creates a classification decision tree that relates properties of each training object to its assigned LUCAS LC/LU class;
- Input features provided for each object include the spectral bands of the five input scenes as well as the NDVI and seasonality layer stacks;
- The created classification tree is then applied to all image objects in order to classify grassland and four main crop types (namely, cereals, maize, root crops, and rape).



Schematic view on the multi-scale approach towards the analysis of seasonal EO data.



Input reference information for the masking of agricultural areas (Geobasis data © German Federal Agency for Cartography and Geodesy - www.bkg.bund.de) and the training of the classification algorithm (top); multi-seasonal EO data set with objects resulting from an image segmentation of the corresponding imagery (center); result of the classification of main crops and grassland (bottom).

Results

- Percentage Overall Accuracy (OA%) of 86.0 and kappa of 0.79 for the considered 5-class problem;
- Cereals (class 1), rape (class 4) and grassland (class 5) exhibit producer (PA) and user accuracies (UA) over 85%;
- Maize (class 2) and root crops (3) show lower PA and UA (i.e., between 63.5 and 78%);
- Misclassifications due to similar seasonal and spectral behavior of root crops and maize as well as maize and grassland;
- NDVI and NIR of LISS-3 May and AWiFS September scene have highest importance, followed by AWiFS July;
- Classification results based on a single scene (05.05.06) is 69.3% and based on two (05.05.06, 12.09.06) is 76.3% OA.

Class	1	2	3	4	5	Samples	UA%
1 (Cereals)	269	7	2	10	27	315	85.4
2 (Maize)	1	33	1	0	7	42	78.6
3 (Root crops)	0	4	10	0	1	15	66.7
4 (Rape)	8	0	1	110	4	123	89.4
5 (Grassland)	20	8	1	5	243	268	87.3
Samples	298	52	15	125	273	763	
PA%	90.3	63.5	66.7	88.0	85.7		OA%: 86.0

Conclusions

- Seasonal time series data enable accurate identification and characterization of main crops and grassland;
- Key issues are i) availability of constant seasonal and spatial coverage of multi-seasonal satellite data for specific dates of the year and ii) adequate reference information;
- Combination of HR and MR imagery ensures achieving a significant coverage with seasonal data and at the same time assuring a high spatial detail of the analysis;
- Presented object-based approach i) has capabilities for multi-sensor, -scale and -season analysis on regional or national scale and ii) is a promising methodology for a frequent monitoring of trends and transformations of LC/LC;
- Key dates for data acquisition are: harvesting season (August-September for Central Europe) and spring season (March, April).

Acknowledgements

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