Rule-Based Framework for Crop Identification Using Temporal and Phenological Metrics: A Multi-Temporal and Multi-Sensor Approach

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Due to growing population and sparse land and water resources, the need grows for enhancing agricultural productivity to ensure food security. Accurate crop maps from earth observation can build the basis for agricultural monitoring at a range of scales. Such maps are one of the essential means to support sustainable land management. In this study, we exploited the intra-annual temporal signatures of remotely sensed observations and used the prior knowledge of crop calendars for the creation of sequential processing chain for crop classification. We applied the method to the study site in Central Ukraine as it has undergone profound changes during the last decades in the extent and intensity of land use. The area is characterized by volatility in agricultural production caused by several drivers such as weather conditions.

Landsat-based time-series metrics that capture within season phenological variation were preprocessed and analyzed using Google Earth Engine cloud computing platform. The development stage of each crop throughout the growing season was modeled using the harmonic regression. The model's output was further used for the automatic generation of training samples. Sentinel-1 images were used as additional input of contextual feature information to classification. Two classification schemes were applied to discriminate the main crops in the study area, namely pixel- and object-based approaches, to classify the following crops classes: winter cereals (wheat, barely), winter rapeseed, maize, soy, and sunflower. Both methods yielded the acceptable levels of accuracies in the range of 80-86 %. By using seasonal composites, overall accuracy exceeded 80 %. Among crop classes, winter cereals were the most accurately classified (Producers accuracy 92 %, Users accuracy 86 %), while we observed misclassifications between soybean and maize. Furthermore, the combined use of the Landsat time series and Sentinel-1 data improved the classification accuracy by 4%. The method was tested in two years which enabled us to study the effect of inter-annual meteorological differences. Based on our results we recommend the use of seasonal composites based on harmonic regression and object-based classification to create accurate crop maps over several years.