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Phenological Metrics Extraction for Agricultural Land-use Types Using RapidEye and MODIS

Xingmei Xu (1), Daniel Doktor (1), and Christopher Conrad (2)
(1) Helmholtz-Centre for Environmental Research-UFZ, Leipzig, Germany, (2) University of Würzburg, Würzburg, Germany

Crop phenology involves the various agricultural events, such as planting, emergence, flowering, development of fruit and harvest. These phenological stages of a crop contain essential information for practical agricultural management, crop productivity estimation, investigations of crop-weather relationships, and also play an important role in improving agricultural land-use classification.

In this study, we used MODIS and RapidEye images to extract phenological metrics in central Germany between 2010 and 2014. The Best Index Slope Extraction algorithm was used to remove undesirable data noise from Normalized Difference Vegetation Index (NDVI) time series of both satellite data before fast Fourier transformation was applied. Metrics optimization for phenology of major crops in the study area (winter wheat, winter barley, winter oilseed rape and sugar beet) and validation were performed with intensive ground observations from the German Weather Service (2010-2014) and our own measurements of BBCH code (Biologische Bundesanstalt für Land- und Forstwirtschaft, Bundessortenamt und CHemische Industrie) (in 2014).

We found that the dates with maximum NDVI have a close link to the heading stage of cereals (RMSE = 9.48 days for MODIS and RMSE = 13.55 days for RapidEye), and the dates of local half maximum during senescence period of winter crops was strongly related to ripeness stage (BBCH: 87) (RMSE = 8.87 days for MODIS and RMSE = 9.62 days for RapidEye). The root-mean-square errors (RMSE) of derived green up dates for both winter and summer crops were larger than 2 weeks, which was caused by limited number of good quality images during the winter season. Comparison between RapidEye and homogeneous MODIS pixels indicated that phenological metrics derived from both satellites were similar to the crop calendar in this region. We also investigated the influence of spatial aggregation of RapidEye-scale phenology to MODIS scale as well as the effect of decreasing the temporal resolution of MODIS to RapidEye scale.

Our method to smooth and construct NDVI time-series works well in monitoring agricultural phenology and can be applied to other areas with daily MODIS data coverage. High spatial resolution data provides us with a unique opportunity to explore within-field phenology variation, and reduce effects of spatial heterogeneity. We suggest that further studies might not have to consider daily or composite-daily observations as first criteria for selection of remote sensing product in terms of phenology extraction, if the crop calendar is reliable.