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Phenological indicators extraction from dense time-series of Landsat data

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Time series of remotely sensed vegetation indices are valuable data sets in various Earth science fields. In particular, they have been successfully used to map vegetation phenology. This information can be used into physically-based hydrological models to estimate crop water requirements (e.g. Pôças et al., 2015; Consoli & Vanella, 2014; Er-Raki et al., 2007).

Most of the phenology detection studies aimed to capture single seasonal crop growth cycles per year. However, the phenological variability in agriculture, especially connected with winter crops interposed to summer crops, demonstrates the necessity of deriving more than one crop cycle per year (e.g. Patel & Oza, 2014; Li et al., 2014). Moreover, remote sensing of phenology has been largely applied using MODIS normalized difference vegetation index (NDVI) data with a spatial resolution of 250 m, which is often not sufficient to resolve highly fragmented agricultural land surfaces. The opportunities for deriving phenological indicators at high spatial resolution improved radically in 2008 when the Landsat program opened its archive (Woodcock et al. 2008).

In this study, we present an approach to detect phenological indicators aimed to characterize vegetation dynamics in agricultural land surfaces. The proposed algorithm was applied to time series of bi-weekly smoothed and gap-filled Landsat Surface Reflectance Climate Data Record (CDR) data from 2012 to 2014 for a pilot area in the Marchfeld region, Lower Austria.

The analytic procedure can be summarized in the following steps. First, the surface reflectance of Landsat CDR data is smoothed and gap-filled using a state-of-the art Whittaker algorithm to create a time series of 24 images per year, regularly spaced in time (Vuolo et al., in preparation). NDVI and fAPAR (fraction of Absorbed Photosynthetically Active Radiation) are then derived and used as input to calculate phenology. Using a moving window approach, the multi-temporal time series are analysed to extract local maxima and minima for each pixel. The resulting values are automatically screened to identify the absolute maxima and minima for each crop cycle. Finally, the algorithm estimates the timing of key phenological periods (i.e. green-up, maximum and senescence) for each pixel. Accuracy assessment is carried out through the visual interpretation of several crop growth curves and using a land cover/land use dataset to analyse the results.

The results show that the method can successfully extract phenological indicators from dense smoothed and gap-filled time series, both for summer and winter crops. In addition, the comparison between phenologies extracted from each vegetation indices (NDVI and fAPAR) shows a good agreement (R^2 = 0.70).

Future effort will be dedicated to apply the proposed approach to Landsat time series for other areas of interest. Furthermore, the method will be improved by calibrating and validating the results for the pilot study based on ground truth data. The phenological indicators will be then assimilated into a hydrological model to estimate crop water requirements at basin scale.