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Statistical modeling of phenological phases in Poland based on coupling satellite derived products and gridded meteorological data

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The aim of the study was to create and evaluate different statistical models for reconstructing and predicting selected phenological phases. This issue is of particular importance in Poland where national-wide phenological monitoring was abandoned in the middle of 1990s and the reactivated network was established in 2006. Authors decided to evaluate possibilities of using a wide-range of statistical modeling techniques to create synthetic archive dataset. Additionally, a robust tool for predicting the most distinguishable phenophases using only free of charge data as predictors was created.
Study period covers the years 2007-2014 and contains only quality-controlled dataset of 10 species and 14 phenophases. Phenological data used in this study originates from the manual observations network run by the Institute of Meteorology and Water Management - National Research Institute (IMGW-PIB). Three kind of data sources were used as predictors: (i) satellite derived products, (ii) preprocessed gridded meteorological data, and (iii) spatial properties (longitude, latitude, altitude) of the monitoring site. Moderate-Resolution Imaging Spectroradiometer (MODIS) level-3 vegetation products were used for detecting onset dates of particular phenophases. Following indices were used: Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI), Leaf Area Index (LAI), and Fraction of Photosynthetically Active Radiation (fPAR). Additionally, Interactive Multisensor Snow and Ice Mapping System (IMS) products were chosen to detect occurrence of snow cover. Due to highly noisy data, authors decided to take into account pixel reliability information. Besides satellite derived products (NDVI, EVI, FPAR, LAI, Snow cover), a wide group of observational data and agrometeorological indices derived from the European Climate Assessment & Dataset (ECA&D) were used as a potential predictors: cumulative growing degree days (GDD), cumulative growing precipitation days (GPD), average monthly temperatures for each month over the previous year for each site, etc.
A few commonly applied statistical methods, including multiple regression, random forest, and neural network techniques were tested and evaluated against the onset dates of phenophases. To avoid overfitting of the models, the dataset was divided into a calibration and a validation period using leave-one-out cross-validation method.
The obtained results show good potential of using statistical models in filling the temporal and spatial gaps in data, as well as, for forecasting selected phenological phases. However, there are some clear limitations of applying modern satellite observation in plant phenology modelling. Therefore, most of the created phenology models are primarily based on agrometeorological indices with only slightly improvements while using satellite derived products.