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Phenological features for winter rapeseed identification in Ukraine using satellite data

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Winter rapeseed is one of the major oilseed crops in Ukraine that is characterized by high profitability and often grown with violations of the crop rotation requirements leading to soil degradation. Therefore, rapeseed identification using satellite data is a promising direction for operational estimation of the crop acreage and rotation control. Crop acreage of rapeseed is about 0.5-3% of total area of Ukraine, which poses a major problem for identification using satellite data [1].
While winter rapeseed could be classified using biomass features observed during autumn vegetation, these features are quite unstable due to field to field differences in planting dates as well as spatial and temporal heterogeneity in soil moisture availability. Due to this fact autumn biomass level features could be used only locally (at NUTS-3 level) and are not suitable for large-scale country wide crop identification.
We propose to use crop parameters at flowering phenological stage for crop identification and present a method for parameters estimation using time-series of moderate resolution data. Rapeseed flowering could be observed as a bell-shaped peak in red reflectance time series. However the duration of the flowering period that is observable by satellite data is about only two weeks, which is quite short period taking into account inevitable cloud coverage issues. Thus we need daily time series to resolve the flowering peak and due to this we are limited to moderate resolution data.
We used daily atmospherically corrected MODIS data coming from Terra and Aqua satellites within 90-160 DOY period to perform features calculations. Empirical BRDF correction is used to minimize angular effects. We used Gaussian Processes Regression (GPR) for temporal interpolation to minimize errors due to residual could coverage, atmospheric correction and a mixed pixel problems. We estimate 12 parameters for each time series. They are red and near-infrared (NIR) reflectance and the timing at four stages: before and after the flowering, at the peak flowering and at the maximum NIR level. We used Support Vector Machine for data classification. The most relevant feature for classification is flowering peak timing followed by flowering peak magnitude. The dependency of the peak time on the latitude as a sole feature could be used to reject 90% of non-rapeseed pixels that is greatly reduces the imbalance of the classification problem.
To assess the accuracy of our approach we performed a stratified area frame sampling survey in Odessa region (NUTS-2 level) in 2013. The omission error is about 12.6% while commission error is higher at the level of 22%. This fact is explained by high viewing angle composition criterion that is used in our approach to mitigate high cloud coverage problem. However the errors are quite stable spatially and could be easily corrected by regression technique. To do this we performed area estimation for Odessa region using regression estimator and obtained good area estimation accuracy with 4.6% error (1σ).

[1] Gallego, F.J., et al., Efficiency assessment of using satellite data for crop area estimation in Ukraine. Int. J. Appl. Earth Observ. Geoinf. (2014), http://dx.doi.org/10.1016/j.jag.2013.12.013