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Estimating relative efficiency of use multisource satellite data for winter wheat yield forecasting in Ukraine

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Crop yield forecasting is an extremely important component of the agriculture monitoring domain, and, consequently, provides a vital input for food security. Earth observation data from space and derived products play an important role in crop yield forecasting as timely and adequate source of data for big areas, and are used most frequently for assimilating variables into the models (for example, crop growth models) or providing variables (for example, vegetation indices) as a predictor in empirical models [1,2].

Ukraine is one of the biggest crop producers in the world. Timely and accurate operational crop yield forecasts for Ukraine at regional level become a key element in providing support to policy makers in food security.

In our previous study [3], we assessed relative efficiency and feasibility of using an NDVI-based empirical model for winter wheat yield forecasting at oblast level in Ukraine.

Though the NDVI-based model provides minimum data requirements, it has some limitations since NDVI is indirectly related just to biomass but not meteorological conditions. Therefore, it is necessary to assess satellite-derived parameters that incorporate meteorology while maintaining the requirement of minimum data inputs.

In our study two new parameters are considered: (i) vegetation health index (VHI) at 4 km spatial resolution derived from a series of NOAA satellites; (ii) Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) derived from SPOT-VEGETATION at 1 km spatial resolution. VHI data are provided as weekly composites and FAPAR data are provided as decadal composites.

The particular advantage of using VHI is that it incorporates moisture and thermal conditions of vegetation canopy, while FAPAR is directly related to the primary productivity of photosynthesis

It was found that VHI, FAPAR and NDVI values taken in April–May provided the minimum error value when comparing to the official statistics, thus enabling forecasts 2-3 months prior to harvest. The best timing for making reliable yield forecasts is nearly the same as it was for the NDVI-based approach [3] (±16 days) – for the most of crop-production regions of Ukraine.

The most accurate predictions for 2011 were achieved using the VHI-based approach with the RMSE value of 0.51 t ha−1 (performance of FAPAR- and NDVI-based approaches was 0.52 t ha−1 and 0.63 t ha−1). At the same time, the most accurate predictions for 2012 were achieved using the FAPAR-based approach with the RMSE value of 0.56 t ha−1 (performance of VHI-based and NDVI-based approaches was 0.7 t ha−1 and 0.68 t ha−1, respectively).

All these approaches underestimated yield in 2011 and 2012 comparing to the official statistics.

Therefore, we can conclude that performance of empirical regression models based on satellite data with biophysical variables (such as VHI and FAPAR) is approximately 20% (from 16% to 23% on different data sources) more accurate (on datasets available at the moment) comparing to the NDVI approach when producing winter wheat yield forecasts at oblast level in Ukraine 2–3 months prior to harvest.

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