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# Multisensor distribution regression for crop yield estimation

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Earth observation (EO) remote sensing data provide a unique source of information to monitor crops in a temporally resolved and spatially explicit manner. This is of paramount relevance given the ever-growing demand of biofuels and food. Traditional remote sensing applications have exploited vegetation indices (VIs) to monitor crop phenology cycles, and have vastly relied on summarizing the time series in a set of spatial and/or temporal descriptors. It is customary to summarize EO time series with temporal metrics like the maximum peak or the start/end of season, as well as to summarize all pixel-based observations within a region with the spatial average. We posit here that summarizing is not a good idea, and propose two nonlinear regression methods to account for all time and space observations that allows blending multisensor (e.g. optical and microwave) observations too.
We illustrate the performance of the methods in two scenarios. First, we combine synergistically optical (MODIS-EVI) and microwave (SMAP-VOD) data using full time series stacked at county level. Such data are then fed into a standard linear and nonlinear (kernel-based) machine learning regression to obtain county-based crop yield estimates over the U.S. corn belt. It is shown that the kernel regression outperforms the linear counterpart, and that the use of full time series from multisensor data improves the results obtained with standard metrics and single sensors. The second experiment takes into account all goals simultaneously. In this case, we follow a distribution regression strategy that does not need to summarize the behavior of a county in an averaged time series. This novel machine learning method exploits higher-order relations between all time series in a county, allows working with the native spatial resolution of each sensor, improves accuracy and bias over previous methods. Results confirm the validity of the multisensor fusion and the advantage of using distribution regression models with full time series for crop yield estimation.