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Is it possible to predict extreme yield loss using climate indicators?

Regional and national yield predictions are based on a variety of systems combining expert knowledge, survey data, and model simulations. These have an important bearing on crop prices and on agricultural stocks. In Europe, yield predictions are made available to the stakeholders several times during the growing season by the MARS crop yield forecasting system monthly bulletin. It relies on an in depth analysis of past climate statistics, seasonal projections of key agro-meteorological variables and – later in the season – crop growth simulations. The skills and limitations of these products are important because they affect EU trade policies. The prediction of extreme yield losses is of particular interest because extreme events have a strong effect on decisions of stakeholders involved in international trade.

In this study, we evaluate the capacity of a large range of indicators to predict the occurrence of extreme yield loss events. Indicators of various complexity levels are considered: simple or combined climate variables, agroclimatic variables and outputs of complex dynamic crop models. Each indicator is used in turn to predict the occurrence of extreme yield loss in France and Spain for both wheat and grain maize. The sensitivity and specificity of the indicators are evaluated by ROC analysis using detrended regional yield time series. Indicators are ranked based on a score quantifying their ability to segregate extreme from non-extreme yield loss events. No single indicator performs systematically well but several show acceptable scores. There is no obvious relationship between the level of complexity of a given indicator and its accuracy. Maximum temperatures and, later in the growing season, potential yield simulations rank highest for both crop species in France. Drought indices perform well in Spain for wheat and maize. The robustness of our ranking is evaluated by comparing the results obtained using several alternative methods. We argue that this transparent framework would be useful to evaluate and improve crop-monitoring systems worldwide. In this perspective we provide a relation linking the most accurate indicators threshold values to the probability of extreme yield loss.