Using a cropping system model for large scale impact assessment in Europe

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Introduction

Agricultural policy of the European Commission aims at improving agricultural sustainability at field, farm, regional and EU scales. Ex-ante assessment of the possible economic, production and environmental consequences of policies may support decision making. The SEAMLESS project (Van Ittersum *et al*., 2008) provides an integrated assessment and modelling platform to support such policy assessments. This platform uses the cropping system model APES (http://www.apesimulator.org/) to predict yields and externalities such as nitrogen leaching of agricultural activities. Like other cropping system models APES operates at the field level using daily time steps. To predict crop yields and externalities at the scale of the European Union APES need to be used for a much larger geographic area. How to do so, and how to evaluate the model at this scale, are the problems addressed in this paper.

Methods

The APES cropping system model includes components that take into account water and nitrogen stress but not yield reductions due to diseases or weeds. Model inputs are daily weather, soil characteristics, initial soil conditions and management practices. A large number of annual crops (cotton, maize, oats, peas, potatoes, rape, rice, rye, sorghum, soya, spring barley, spring soft wheat, sugar beet, sunflower, triticale, winter barley, winter soft wheat, winter durum wheat) can be simulated in rotations.

The first problem in using a field level model for a large area is the spatial soil-climate heterogeneity. Therefore, Europe is divided into zones with relatively homogeneous properties from an agronomic perspective. In SEAMLESS, Europe is divided into AgroEnvironmental Zones (AEnZ), which are combinations of 13 environmental zones (primarily based on statistical analysis of climate and geomorphological variables), a soil classification (based on 6 topsoil organic carbon classes) and NUTS2 administrative regions (Baruth *et al*., 2006). A total of 195 AEnZ in 16 sample regions (from Andalucia-Spain to Etela-Suomi-Finland and from Southern and Eastland-Ireland to Thessalia-Greece) have been chosen to represent the biophysical conditions of Europe. For each AEnZ, historical weather (from the MARS database) and soil characteristics (from the European soil database) are available.

Classical model evaluations for APES have been carried out at the field level (Adam *et al*., 2009; Casellas *et al*., 2009), but for large areas it is important to add an additional evaluation allowing to compare model results with corresponding observed values in each AEnZ, for a range of regions throughout Europe. Therefore, current management practices for the major crops in each AEnZ need to be specified. Such data do not exist at a pan-European level; the Farm Accountancy Data Network (FADN) contains data about input use but at the farm level rather than the crop level, and does not specify timing of input use. We therefore developed a new data base, taking advantage of the fact that SEAMLESS has a large number of partners throughout Europe. These partners identified local experts who in turn specified the major regional crop rotations and associated yield levels. In addition, the experts estimated average (over fields and years) management activities for these crops, i.e. sowing and harvesting date, nitrogen input, total amount of irrigation water and number of irrigations. Then, based on that information, experts and agronomists developed generic decision rules specifying detailed management practices for each crop (Oomen *et al*., 2009). These management rules are important not just for quality evaluation of model outputs, but also for simulation of current practices.

The APES model has simulated 21 crops in each AEnZ of the 16 sample regions, for a period of 25 years. The first five simulation years are used for initialization of the soil conditions. Average date of physiological maturity (assumed to be the same as harvest date in expert data) and average yields are calculated using results from the remaining 20 years. Three criteria are used to assess the agreement between model and observed data. First, we calculate the average number of degree days up to the 'observed' (i.e. expert value) harvest date for each AEnZ. This value can be compared to the model parameter value that represents the required number of degree days to maturity (determined by modellers according literature information and field level calibrations). The ratio of the two is the first error factor, k_{pheno}. Secondly, simulated yields in each AEnZ are compared to the yields as specified by local experts. The ratio is the second error factor, k_{yield1}. Finally, one can first calibrate the phenology parameters of the model (by multiplying all these parameters – that represent degree days to different phenological stages – by k_{pheno}) and then calculate a new yield error factor k_{yield2}. The difference between k_{yield1} and k_{yield2} indicates to what extent the error in yield can be reduced by correcting for the errors in phenology. Remaining errors can still refer to many issues, i.e. misspecification and parameterization of the model, flaws in soil, climate and agro-management data, and to the fact that pests and diseases are not modelled in APES. Runs of APES and calculation of the error factors are currently underway and will be presented at the Conference.

Results and discussion

The feasibility of using a cropping system model at the scale of Europe is closely related to the availability of input data and evaluation data. In general, weather and soil data are available in existing European data bases resulting in the AEnZs as described. The model can be run for given management to predict yields and environmental effects at European scale. For model evaluation, we have created a new data base that contains current crop management and evaluation data for AEnZ throughout Europe, based on expert opinions.

The assessment criteria as discussed here serve two functions. Firstly, they indicate the degree of agreement between model and observed data. It will be of particular interest to analyse systematic patterns in the error factors, e.g. across regions. Secondly, the error factors can be used as correction factor to modify model outputs. The effectiveness of such a factor in improving prediction of externalities and estimation of alternative agro-management options still needs to be assessed.

References

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