J. Plant Develop.
16 (2009): 97–102

ADAPTATION OF WOFOST MODEL FROM CGMS TO ROMANIAN CONDITIONS

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Abstract. This preliminary study is an inventory of the main resources and difficulties in adaptation of the Crop Growth Monitoring System (CGMS) used by Agri4cast unit of IPSC from Joint Research Centre (JRC) - Ispra of European Commission to conditions of Romania.

In contrast with the original model calibrated mainly with statistical average yields at national level, for local calibration of the model the statistical yields at lower administrative units (macroregion or county) must be used. In addition, for winter crops, the start of simulation in the new system will be in the autumn of the previous year. The start of simulation (and emergence day) in the genuine system is 1st of January of the current year and the existing calibration was meant to provide a compensation system for this technical physiological delay.

Proposed approach provides a better initialisation of the water balance (emergence occurs after start of simulation), as well as a better account for impact of wintering conditions, but obviously a new calibration for all cultivar dependent parameters is necessary. For the preoperational run, the localized model will use the weather data available till the last day available and the missing data from the rest of the year will be replaced either by the daily values of the long term averages or by the values from a year considered similar with the current one.

Proposed adaptations permit a better use of information available on local scale and the localized model may be the core of a regional system for crop monitoring and in the same degree as the original system it can be used as tool for specific researches, such as studying the impact of climate changes.

Key words: crop growth monitoring, CGMS, WOFOST model, phenology, climate change

Introduction

Crop Growth Monitoring System (CGMS) is currently operationally used by the Monitoring Agricultural Resources Unit (MARS) of Institute for Protection and Security of the Citizen from the Joint Research Centre (JRC) Ispra of European Commission.

The central element of CGMS is represented by a version of WOFOST [SUPIT & al. 1994] projected by ALTERRA (Wageningen) company at the request of MARS unit for monitoring of the main crops (winter wheat, spring barley, grain and fodder maize, sunflower, dry beans, potatoes, sugar beet, and rapeseed) for whole Europe, as well as for evaluating food security problems in the main risks areas of the world. It was also used to evaluate the impact of climatic changes on agricultural production (Fig. 1). In the last years operational models like WARM (for rice) and LINGRA for pastures and grassland productivity monitoring were added. The main customers are General Direction for Agriculture of European Commission and EUROSTAT, but there are a lot of scientific studies which used

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the infrastructure of CGMS, its modified WOFOST model or outputs of that model. The system is continuously improved and almost each year calls for tender for research projects aiming the improvement of one or another component of the system are posted.

CGMS is structured on three levels. The first level is dedicated to agro-meteorological aspects [MICALE & GENOVESE, 2004] and has a main product a meteorological database updated daily for each of the 25 × 25 km (50 × 50 km in the previous version and public applications) cells grid covering the whole surface of Europe.

The meteorological data, together with soil data, species and cultivar dependent coefficients as well as crop calendars are used in the next level by the WOFOST, LINGRA or WARM models [LAZĂR & GENOVESE, 2004]. Fig. 3, presenting the low level of the simulated winter wheat biomass under non-irrigated conditions, is an example of the model outputs. The remote sensing data (Fig. 2) are used to confirm this situation. The model used operationally by JRC is not optimised for the simulated yields. The results of simulation (development stage, LAI, relative soil moisture, total biomass, and storage organs biomass in potential and water limited conditions) in various combinations are used in a complicated statistical platform (level 3 of CGMS) to detect the most similar years with the current year for the target area. The de-trended statistical yields from these years are weighted with a similarity index and averaged to propose several possible forecasts to the country analyst. Unfortunately, the elements of this level are the most difficult to transfer to new users.

Besides the advantage of using a methodology confirmed on European level [VAN DIEPEN & BOOGARD, 2009], this system, which may be free downloaded, represent a research instrument which, with required adaptations, may be applied in various studies concerning the relationship between plant, soil and atmosphere. In addition there is the idea that the model could be easier tuned up for a less extended geographical area.

Although a large part of the required input data may be picked up freely from various internet sources, several difficulties are expected to occur in this process. Elaboration of an inventory of available resources and discussion of the expected problems is the first logical step on the path of system adaptation.

This preliminary study shows and discuses the main difficulties related to a possible adaptation of the model from Crop Growth Monitoring System (CGMS) to Romanian conditions.

Materials and methods

The version 9.2 of the CGMS model was downloaded from < ftp://mars.jrc.ec.europa.eu/CGMS >. The "User's manual" and a technical documentation are included in the installation kit. The version 8.0, documented by [SAVIN & al. 2004] is also available on the same site.

The internet sources able to provide (in an accessible format,) time series of data, long enough for calibration for all Romanian territory were identified for each category of input data. The possible local data providers and national competence sources were also mentioned.

Results and discussions

For level one, the daily meteorological data (maximum and minimum temperatures, precipitation, solar global radiation and potential evapotranspiration) for each cell (50 × 50 km) of the grid, but for a limited number of years, and grid cells may be obtained from a special JRC site <http://marsimg.jrc.it/datadistribution/ExtractGrid.php> on written request.

Due to the fact that WOFOST model may run also with 10 days or monthly weather data, one could try to pick up the 10 day averages of weather data from the meteorological maps (Fig. 2) saved as CSV files (option included in the graphical user interface) from the site of MARSOP project <http://www.marsop.info>. An alternative information source may be represented by the weather data recalculated with a global circulation atmosphere model. Ten days averages from ERA40 may be downloaded from another JRC site < http://marsimg.jrc.it/datadownload/index.php>, but the data are delivered in two grids (cells with size of one degree or, for a shorter time series, with cells sized at a quarter degree) which are different from the grid in which data are available in MARSOP site. For the last two alternative sources a sensibility study for the WOFOST is first necessary. The only internal possible provider identified is the National Meteorological Agency, but the data cost is relatively high.

The second level uses, besides the weather data, a description of the soil profiles and cultivar dependent coefficients. The soil information, harmonized at European level in a format CGMS compatible [BARUTH & al. 2006] may be accessed from < http://eusoils.jrc.ec.europa.eu/library/data/sinfo > after fulfilling a registration procedure. Crop calendars for various areas of the new member states and some phenological data were collected in the MOCA project [KUCERA & GENOVESE, 2004]. Filling of the table „VARIETY_PARAMETER_VALUE" from CGMS database is difficult both to the lack of data for calibration and optimisation of the coefficients determining the physiological behaviour of the cultivar. For version 8.0, for the whole European space, only ten winter wheat "cultivars" were initially used to explain the intraspecific differences in crop behaviour. In many cases, the only available solution for a very large geographical area consists in adjustment of anthesis and maturity days by changing two coefficients indicating the thermal requirements, till the timing for these two events indicated by an expert opinion is reached. These thermal requirements are calculated with thermal thresholds characteristic for each simulated crop. After that, the model may be forced towards one of parameters combinations that simulate with an acceptable accuracy the yield for the target administrative unit and keeping also the other simulated crop variable (like leaf area index and biomass) in the physiological range. Agri4cast realised a calibration platform named CALPLAT able to optimise calibration process, avoiding for example the risk for selection of a local minimum. For calibration of the winter wheat, we propose the use of a more complex model (accounting for photoperiod and vernalisation) like Ceres-Wheat from DSSAT platform for which there are already several calibrated Romanian cultivars from different periods [LAZĂR, 2000].

The beginning of simulation for the winter cereals in the original system is on 1st of January of current year. The same day is used for simulated emergence. The use of sowing day in October will bring the necessity of new calibration. The new calibration presumes larger thermal requirements for the interval between emergence and flowering. This choice received an additional justification (especially for the areas in Eastern Europe) through introduction in the WOFOST [LAZĂR & al. 2005] of a module for simulation of the frost damages from the CERES model [RITCHIE, 1991].

For the local calibration of the model it is advisable to use the statistic yield reported at county level or at macroregion level rather than yield for the national level. The intersection in a geographical informatics system of the grid cells with the geographic boundaries of the soil units, with the information regarding the presence of arable land (CORINE Landcover or PELCOM) and with boundaries of the administrative units will be necessary.

For preoperational run, the localized instance will use the weather data available till that moment and the missing data till the end of the vegetation season will be filled with the daily data from the long term average or from the most similar year detected by a cluster or principal component analysis, using the facilities implemented in version 9.2.

The proposed adaptations will permit a better use of information available on local scale, and the localised model may represent the core of a local system for yield monitoring or an instrument for studying the impact of climate change on phenology and productivity of the crops. An example in this sense is the use of WOFOST model from CGMS for assessing the impact of climate variations observed in the period 1975-2003 on winter wheat phenology [GENOVESE & al. 2004]. These changes induced a three week reduction of the duration between sowing and flowering in some areas of western Europe.

Transfer of level three is very difficult due to the fact that the statistical analysis system is complex and the component COBO (Control Board) runs in an ORACLE environment and its replication is costly. After the assimilation of the first two levels it will be possible the design of local yield forecasting system if the elements included in version 9.2 will not be enough.

One may notice the possibility of parameterization of WOFOST model for simulation of phenology and growth for various annual herbaceous wild species, but a considerable amount of knowledge regarding the target plant is necessary.

Conclusions

The WOFOST model and the Crop Yield Monitoring System built around it is an interesting tool for study the plant-soil-atmosphere interactions.

The adaptation of the system for Romania seems possible and the sources for preliminary calibration were indicated.

The performance improvement of the WOFOST in the new adaptation may come from the calibration procedure and in case of winter crops from the simulation of the impact of the winter conditions.

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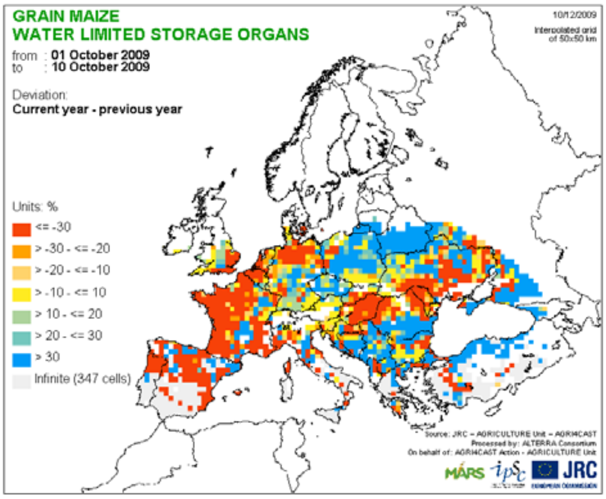

Fig. 1

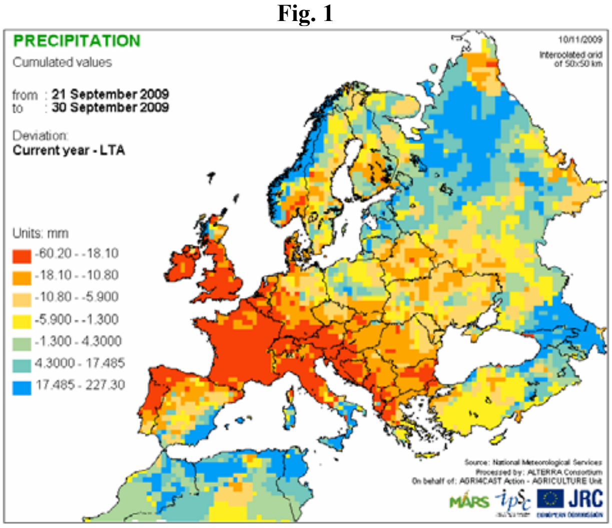

Fig. 2

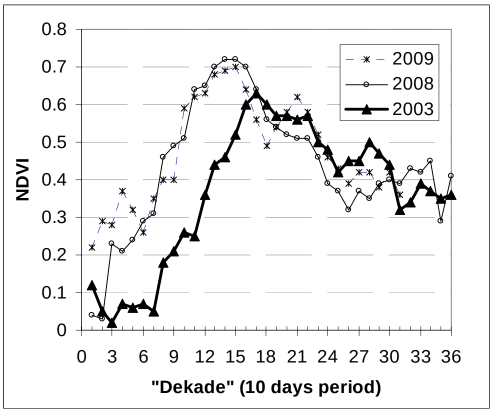

Fig. 3

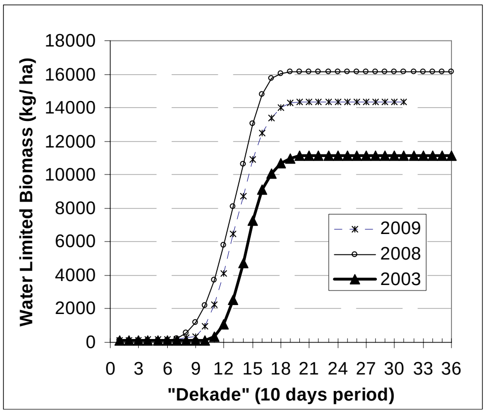

Fig. 4

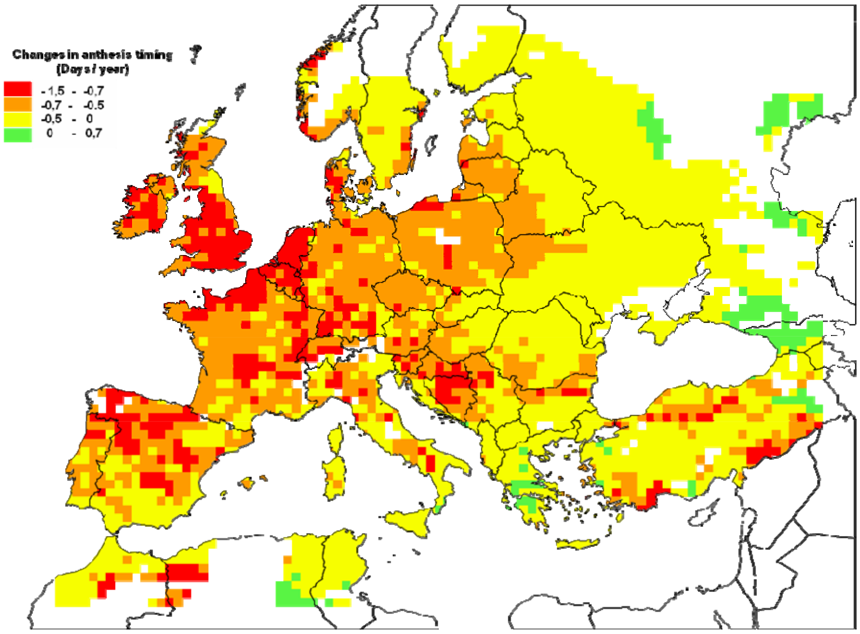

Fig. 5