CROP MONITORING IN EUROPE

Giovanna Fontana[1], Bettina Baruth[1], Stefan Niemeyer[1]

[1] European Commission, Joint Research Centre, via Fermi 2749, 21027 Ispra (VA)
[*] giovanna.fontana@jrc.ec.europa.eu

Abstract
The need of the European Commission, Directorate General for Agriculture for early European figures on crop production led to the development of the MARS activities in the beginning of the nineties. A crop yield forecasting system was put in place to supply early information on development and growth conditions of crops during the campaign as well as to forecast crop yields.

Keywords: MARS (Monitoring Agricultural ResourceS), MCYFS (Mars Crop Yield Forecasting System), Crop yield forecast, Crop growth model

Introduction

For implementation of the **C**ommon **A**gricultural **P**olicy (CAP), the European Commission requires information on European crop production of the current growing season. To acquire this information, the MARS-project (at that time: Monitoring Agriculture with Remote sensing) was started 20 years ago. The MARS-project is now running in an operational context what is called the MCYFS (Mars Crop Yield Forecasting System) to provide short term forecasts for the main European crops.
The project uses near real time data like observed weather, weather forecasts and remote sensing data. On regular intervals new yield statistics are added. Static input data consist of soil maps, crop parameters and administrative regions. With these input data crop conditions are simulated and crop specific end-of-season yield forecasts are made. With software tools the data can be accessed, analysed and presented. While the operational running of the needed crop growth models and software tools has been outsourced, the Mars Unit is in charge of research and development, main output quality control, analyses and publication of the MARS bulletins.

MARS Crop Yield Forecasting System

The Joint Research Centre has been developing and operationally running a Crop Forecasting System since 1992 in order to provide timely crop production forecasts at European level. This system is able to monitor crop vegetation growth (cereal, oil seed crops, protein crops, sugar beet, potatoes, pastures, rice) and include the short-term effects of meteorological events on crop productions and to provide yearly yield forecasts on European crops.
The MARS Crop Yield Forecasting System, is made by remote sensing and meteorological observations, agro-meteorological modelling (Crop Growth Monitoring System (CGMS), MARS Model Library) and statistical analysis tools.
CGMS monitors crops development in Europe, driven by meteorological conditions modified by soil characteristics and crop parameters. This mechanistic approach describes the crop cycle (i.e. biomass, storage organ …) in combination with phenological development from sowing to maturity on a daily time scale.
The main characteristic of CGMS lies in its specialization component, integrating interpolated meteorological data, soils and crops parameters, through elementary mapping units used for simulation in the crop model. This system can be considered as having three levels:

1. Management of a meteorological data base (Level 1: Weather monitoring);
2. Management of an agro-meteorological model and data base (Level 2: Crop simulation);
3. Statistical analyses of data produced and crop yield forecasting at the European level (Level 3: Yields forecasts).

Level 1: Weather monitoring

The weather monitoring component is one of the main elements of the MCYFS (Genovese G., 2001).
Every day the raw data of at least 3000 stations that regularly collect and supply one or more indicators are acquired and added to the raw station weather database.
Most basic indicators like precipitation, temperature and wind speed can be directly retrieved from weather stations; while solar radiation and evapotranspiration are calculated from basic indicators.
In addition also weather forecasts (from ECMWF) are loaded. This has the advantage that crop yield can be simulated until the end of the crop season and can be used to make Yield Forecasts
The data is processed daily and quality checked and interpolated to a 25 x 25 kilometer grid.

Level 2: Crop simulation

The crop simulation takes three major factors into account: weather, soil and crop characteristics. For each of these factors input data are required. In order to have the output data also available for administrative regions such as countries or provinces also these should be known to the system.
The core of the CGMS is the crop growth model WOFOST. It simulates biomass accumulation and crop development showing the effect of recent weather on crop growth.
The model calculates intercepted light and convert this into plant matter (potential gross photosynthesis). When there is not enough soil water available the potential plant matter is reduced (actual gross photosynthesis). After substracting maintenance costs (maintenance respiration) the newly formed plant matter is distributed over different plant organs:

roots, stems, leaves and storage organs (grains/tubers). Depending on the age of the plant (DVS which is driven by temperature) the different organs receive different shares. During the conversion from plant matter into organs part of it is lost as construction costs (growth respiration).
Early in the season, most of the plant matter is invested into roots, stems and leaves. With more leaves also more light can be intercepted and plant growth increases rapidly. Towards the end of the season all or most of the plant matter is converted into storage organs and leaves start to decay therefore reducing light interception and thus reducing plant growth. Grains are ripening.
The CGMS produces crop indicators like 'above ground biomass', 'biomass of storage organs', 'crop development stage' and others. These indicators provide insight in the crop season conditions.

Level 3: Yields forecasts
The objective of the yield forecast is to provide the most likely, precise, accurate, scientific, traceable and independent forecasts for the main crops' yields at EU level taking into account the effect of weather during the season as early as possible during the cropping campaign (and until harvest).
The forecasted crop yield is calculated with a combination of methods and software tools. It is assumed to be a function of the trend of observed yields, possibly corrected with a function of one or more indicators from elsewhere out of the MCYFS and closed with a residual error:

Forecasted yield = f(t) + f(i) + residual error

Where:
f(t) = function of the trend of observed yields over the last 10 years
f(i) = optional function of one or more indicators that originate from other parts of the MCYFS.

At the end of the process different possible forecasts are available. The "most performing result" is then individuated and selected according to statistical test.

Remote sensing
Remote sensing data is used as an independent source of information to confirm crop growth indicators and forecasts with the help of vegetation state indicators and weather indicators. Mainly vegetation state parameters are derived from sensors SPOT-VEGETATION, NOAA/METOP-AVHRR, and TERRA-MODIS, like NDVI and fAPAR.

Mars Bulletin
The results of the yield monitoring activities, at national level, are published in the MARS Bulletin containing analysis, forecasts and thematic maps on crop yield expectations.
The MARS bulletins offer in a near real time and in an operational context analyses and information on crop growth conditions and yield forecast at EU27 level and neighbouring countries like Ukraine, Black Sea area and Maghreb.
The crops covered are wheat, barley, rice, maize, rye, triticale, rapeseed, sunflower, sugar beet, potato and pastures.
Along the crop growth season MARS Bulletins include different kind of information reaching from an agro meteorological analysis based on observed and simulated weather to the issuing of short term forecasts based on the output of crop growth models.
The analyses in the Bulletin include a comparison of current year crop indicators with long term average indicators, that can reveal early or late phenological stages or more or less than normal biomass accumulation. In this way anomalies in regional weather conditions and the consequences for crop growth are detected early, providing a basis for alarm warnings or relief measures (van Diepen and van der Wal, 1995).
The Bulletin archive gathers all Bulletins published since 1997.
(http://mars.jrc.ec.europa.eu/mars/About-us/AGRI4CAST/MARS-Bulletins-for-Europe).

References
Genovese G, Baruth B, Royer A, Burger A. MARS STAT action of the European Commission - Crop and Yield Monitoring Activites. GeoInformatics 10 (4); 2007. p. 20-22. JRC35580

Genovese G. (eds). 2004. Methodology of the MARS Crop Yield Forecasting System. In: European Communities (ISBN 92-894-8180-3)

Diepen, C.A. van, Wal, T. van der, 1995. Crop growth monitoring and yield forecasting at regional and national scale. In: J.F. Dallemand, P. Vossen (eds). Workshop for Central and Eastern Europe on agrometeorological models: theory and applications in the MARS project, 21-25 November 1994, Ispra, Italy. EUR 16008 EN, Office for Off. Pub. of the EU, Luxembourg, p 143-157.