Interdisciplinary Research Group for Promoting Climate-Smart and Sustainable Agriculture (AgroMo) (GINOP-2.3.2-15-2016-00028)

(Supplemental material for the "Introduction to the AgroMo modelling framework" workshop)

1. WHAT IS THE AIM OF THE AGROMO PROJECT?

The project aims to contribute to the sustainable and climate-friendly development of Hungarian agriculture by establishing a complex, interdisciplinary experimental environment and by implementing a so-called Integrated Assessment and Modelling (IAM) software. IAM implementation can quantify future development of national agricultural production in the light of climate change factors and various agro-economic scenarios.

2. WHAT IS THE RATIONALE BEHIND COLLABORATION OF DIFFERENT SCIENTIFIC AREAS?

Weather and agrotechnology are the main drivers of the observed agricultural yields which, in general, affect farmer's profit. However, explicit quantification of the effect of natural impacts and various human factors is difficult due to the complexity of the processes and uncertainty of potential supplementary factors. In addition, multifactor climate change poses a huge challenge on farmers. **Therefore, the ultimate question is: how can we take into account the combined effects of human decisions and environmental conditions?** Joint work of agronomists, plant physiologists, climate researchers and soil scientists may potentially answer this fundamental question.

SZÉCHENYI 2020
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3. HOW CAN WE QUANTIFY THE DISTINCTIVE EFFECTS?

The solution is the development of computer-based mathematical models. For many years our team has been devoted to develop the combined crop/biogeochemical model called Biome-BGCMuSo. The model includes the most important determining factors of crop yield formation and represents the biological and chemical processes in the plant/soil system with realistic field environment simulation. The AgroMo framework integrates series of observations and real management datasets for model optimization, thus it is able to accurately estimate the amount of yield and aboveground biomass in terms of environmental conditions and agromanagement. **The Biome-BGCMuSo[1] model based IAM is the principal outcome of the AgroMo project.**

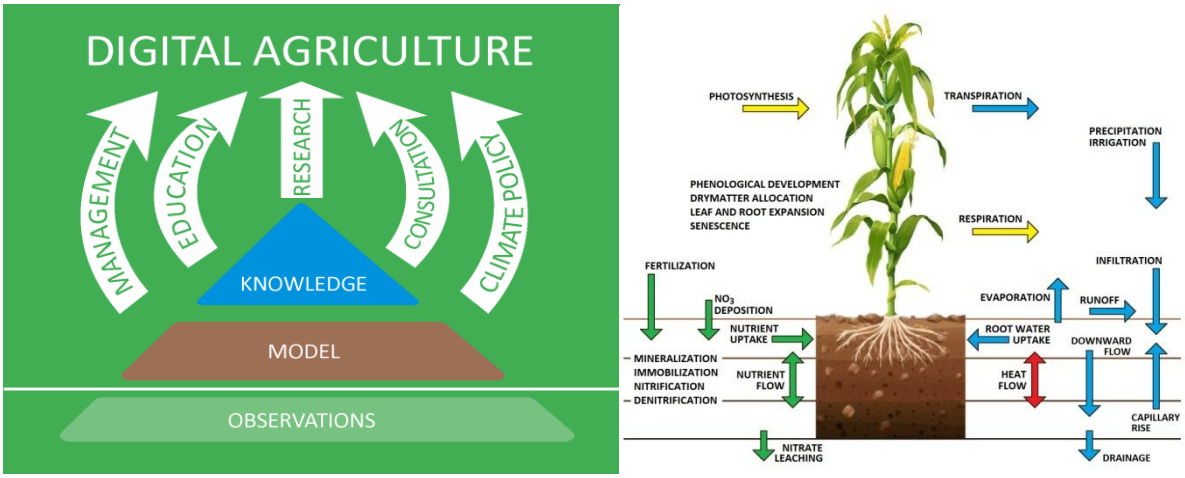

Figure 1. Left: the position of the model within the AgroMo logic. Right: schematic of the processes represented by the Biome-BGCMuSo model.

4. HOW CAN WE USE THE COMPUTER MODEL?

Like in case of any computer-based model, the usage of Biome-BGCMuSo requires expert knowledge. **One primary goal of the AgroMo project is facilitating the easy applicability of the model.** Therefore, we create the so-called AgroMo-CLI (i.e. AgroMo Command Line Interface) that provides a simple way for everyone to handle the model. **The purpose of the workshop is to introduce and present the appropriate use of AgroMo-CLI.**

[1] http://agromo.agrar.mta.hu/kapcsolatok.html

5. AgroMo-CLI BASICS

In order to use AgroMo-CLI, first we have to install the free „R" software environment on our computer. We will also need the RTools software. At present AgroMo-CLI is available at GitHub, which means that we will need to install the so-called „devtools" package within R. Given that we have a complete simulation set with Biome-BGCMuSo we can easily create a plot using a few simple commands within R:

```
install.packages("devtools")
devtools::install_github("hollorol/RBBGCMuso/RBBGCMuso")
library(RBBGCMuso)
mysettings<-setupMuso()
plotMuso(settings=mysettings,variable=27)
```

The result of these commands is shown in Fig. 2. Similarly, we can easily perform sensitivity analysis with Biome-BGCMuSo (which is generally a complex mathematical and programming problem):

```
parameters <- read.csv("parameters.csv")
musoMonte(parameters=parameters,iterations=1000,varIndex=8)
musoSensi(parameters=parameters,monteCarloFile="./calib/epc.csv")
```

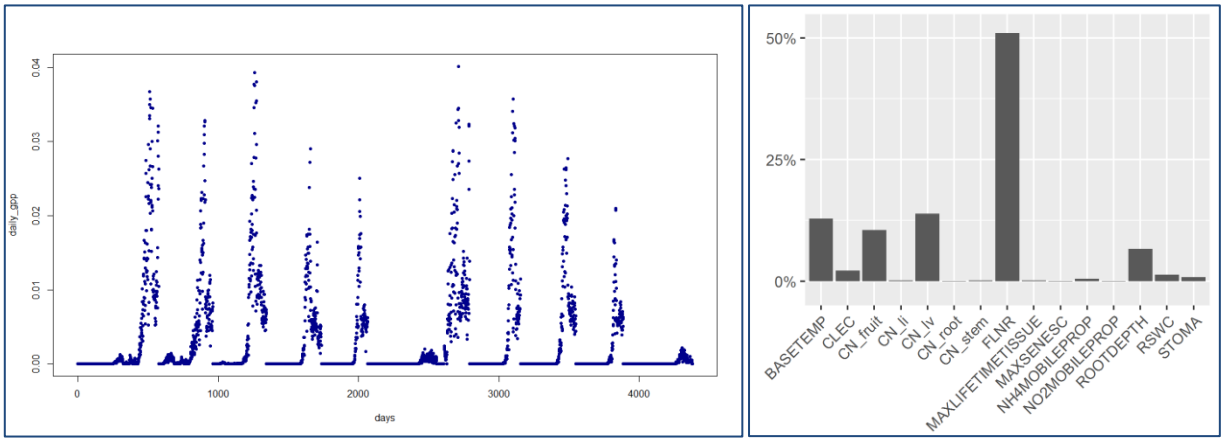

Figure 2. Left: sample plot created using the R commands described above (daily_gpp: gross photosynthesis in daily time step expressed in carbon mass equivalent, kgC/m^2/day). Right: result of the sensitivity analysis of the model. The ecophysiological parameters of Biome-BGCMuSo are shown in the x axis; e.g. BASETEMP (base temperature), CN_lv (carbon:nitrogen mass ratio in leaves), FLNR (fraction of total live leaf nitrogen occurring in the RuBisCO enzyme), etc. Column height is proportional to the importance of the given parameter in terms of a given process.

6. FURTHER SIMPLIFICATIONS – GRAPHICAL USER INTERFACE

It is one of the strategic objectives of the AgroMo project to create and disseminate a software tool that is easily available and applicable for a wide range of possible users like stakeholders and decision makers. This will be accomplished by the creation of a Graphical User Interface (GUI) with multiple levels of accessibility. The simplest interface (called AgroMo-*lite*) will only enable the user to change the management options for a site-level simulation. Experienced users will have access to the complete set of options, and ultimately the GUI will support simple execution of country-wide crop yield simulations taking into account the effect of climate change and human decisions (see Fig. 3).

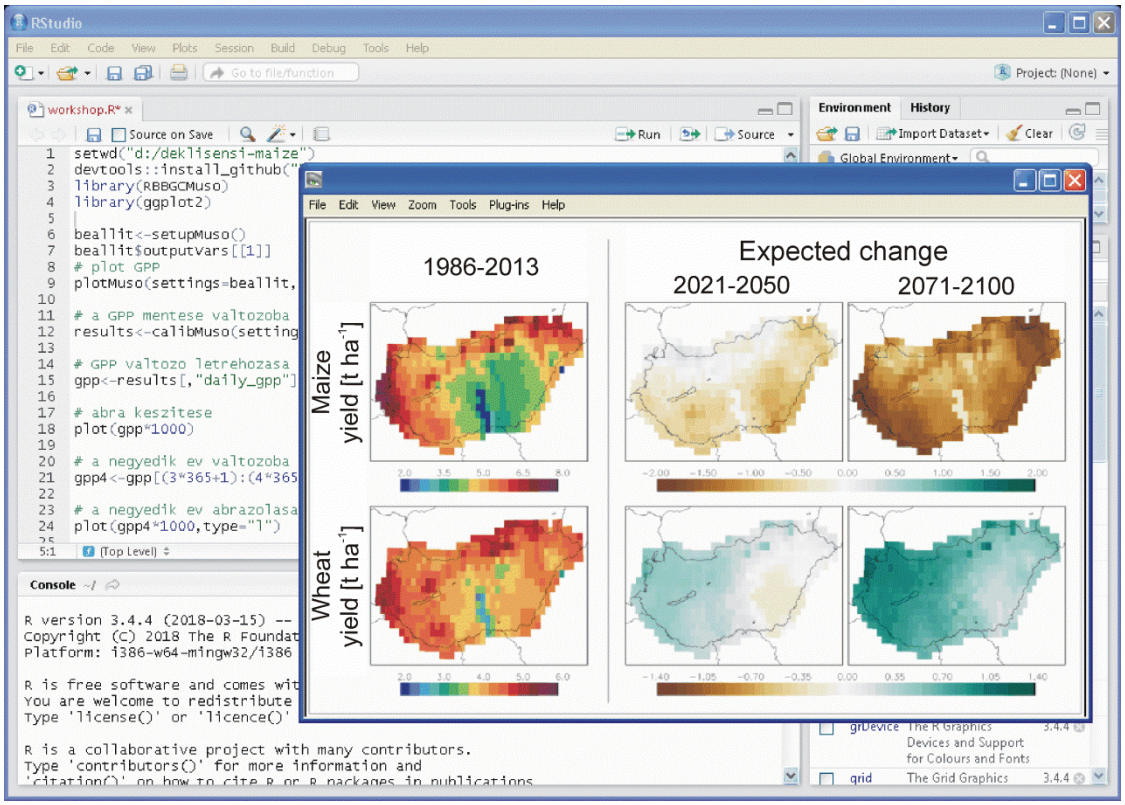

Figure 3. Visualization of a country-scale virtual crop yield experiment using the GUI. Based on the planned GUI it will be very simple to perform such experiments without any programming or deeper modelling experience.