PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXVI cycle, 2020-23)

Project draft

1. Field of interest

AGR/02 - Agronomia e coltivazioni erbacee

2. Project title

Downscaling biophysical simulation using earth observation to increase the transferability of precision agriculture principles to operational farming conditions.

3. Tutor (membro del Collegio dei Docenti): Prof. Roberto Confalonieri (matr. 16605)

- Eventually: co-tutor/s

4. Relevance of the topic and state of the art:

Precision agriculture aims at optimizing agricultural practices in time and space. The more optimized the practices, the larger the environmental and economic benefits. However, the underlying assumption is the availability of a suite of technologies able to quantitatively assess crop needs by capturing temporal dynamics and spatial patterns.

Multiple processes (involved, e.g., with physical and chemical soil properties, micro-climate, biotic and a-biotic factors) lead to discontinuities within field that needs to be accounted for. Earth observation can support the detection of differences while smart scouting-driven *in situ* measures and biophysical modelling can complement the information (Nutini et al.,2018). The workflow above guarantees to deliver timely advises for optimizing agricultural practices at different spatial scales (Paleari et al, 2019). Despite forcing approaches based on the assimilation of remote sensing information (e.g., Pagani et al., 2019) demonstrated their usefulness to support the use of crop models for monitoring purposes, their integration in crop model simulation to support management at subfield scale is still far from being available in operational contexts (Gilardelli et al, 2019).

The aim of this project is to develop an integrated framework for analyzing the reasons for the within-field variability to provide farmers with spatially distributed diagnoses to successfully apply precision agriculture principles.

5. Layout of the project (draft)

5.1. Materials & Methods:

When biophysical models need to be used to support the implementation of precision agriculture principles, detecting and managing key sources of uncertainty in the quantification of drivers require to fully explore the different domains they may derive from. Available biophysical model algorithms will be the ground for the implementation of ensembles that will constitute the simulation engine. This will allow developing a framework suitable for a wide range of target species and management practices, a fundamental requirement for interpreting the micro-scale processes generating the observed effects. The main focus will be on wheat-, rice- and corn-based cropping systems, and on vineyards. Concerning earth observation data, the main sources of information will refer to remote sensing programs targeting public availability of products (like those carried out by ESA and NASA).

The assimilation of remote sensing information during the biophysical simulation will target the closest relationship between the observed effects and the parameters involved with the processes that drove those effects. Therefore, parameters that will be optimized will not be involved with plant traits, given this would force the simulation to comply with the remote observation of effects without understanding the underlying reasons, thus preventing the use of biophysical models to interpret reality in diagnostic terms and consequently to provide information on how optimizing management practices in space and time. Parameters that will be optimized will be thus involved with heterogeneity in physical and chemical soil properties, as well as with their interaction with anomalies in the way previous management practices have been applied. Input data will also include real-time and forecasted weather series with different characteristics and from different sources. The superposition of variables defining the simulation environment will be carried out based on the later effects and their causality linkage.

Dedicated field experiments will be carried out, even generating variability to mimic the effects of, e.g., within-field differences in nutrients availability or local anomalies in sowing density.

5.2. Schedule and major steps (3 years):

During the first year, earth observation data from different sources will be analyzed and reviewed in light of their potential to support spatially distributed diagnoses on crop conditions. Automated processing chains will be developed for the most promising ones. The same (analysis and review) will be done for the available biophysical crop models. The most suitable for the project objectives will be implemented in a dedicated simulation engine.

The second year, the framework for integrating (based on the verification of different assumptions on the causes) earth observation data and bio-geochemical simulation tools will be designed and developed.

During the third year, the whole system will be tested and validated using the data collected in experimental fields and via surveys performed in operational farming conditions.

Dedicated field experiments on summer and winter corps will be carried out along the three years.

6. Available funds (source and amount)

Different projects from regional, national and European calls, more than 200k euros on this research line.

7. Literature:

Gilardelli, C., Stella, T., Confalonieri, R., Ranghetti, L., Campos-Taberner, M., García-Haro, F. J., Boschetti, M., 2019. Downscaling rice yield simulation at sub-field scale using remotely sensed LAI data. European journal of agronomy, 103, 108-116.

Nutini, F., Confalonieri, R., Crema, A., Movedi, E., Paleari, L., Stavrakoudis, D., Boschetti, M., 2018. An operational workflow to assess rice nutritional status based on satellite imagery and smartphone apps. Computers and electronics in agriculture, 154, 80-92.

Pagani, V., Guarneri, T., Busetto, L., Ranghetti, L., Boschetti, M., Movedi, E., ... & Ricciardelli, E., 2019. A high-resolution, integrated system for rice yield forecasting at district level. Agricultural systems, 168, 181-190.

Paleari, L., Movedi, E., Vesely, F. M., Thoelke, W., Tartarini, S., Foi, M., ... & Confalonieri, R. (2019). Estimating crop nutritional status using smart apps to support nitrogen fertilization. A case study on paddy rice. *Sensors*, *19*(4), 981.