Geophysical Research Abstracts
Vol. 14, EGU2012-9588, 2012
EGU General Assembly 2012

Prediction of grain yield using optical remote sensing and a growth model: application on Merguellil catchment (Tunisia)

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In semi-arid region and especially in irrigated areas, agriculture represents a major contribution to food security. These areas significantly contribute to the increase of global production. A challenging objective is thus to ensure food security. Therefore an operational forecasting system for the grain yields is required and could help decision-makers to make early decisions and plan annual imports. In this context, remote sensing is a very interesting tool for giving information on the development of vegetation. The main objective is to analyze and predict the average grain yield, based on different indices measured or modelled during the growing season. Thus, we used three lines of research: the first is based on analysing a relationship between normalized vegetation index (NDVI) which is determined from optical satellite imagery and the leaf area index (LAI) measured in situ. The second axis is based on the estimation of the relation between wheat yields and normalized vegetation index NDVI. The third axis is based on the application of a growth model SAFY « Simple Algorithm For Yield Estimate » developed to simulate LAI, dry aboveground phytomass (DAM) and the grain yield (GY).

For the first axis, we used optical data at high resolution. A series of 7 SPOT / HRV during the 2010-2011 agricultural seasons was acquired in the Merguellil catchment (Tunisia). At the same time we realised experimental measurements made on 27 test plots of dry or irrigated cereals carried out in study area. These measurements are mainly: the water content of the vegetation, the vegetation height, wheat density and leaf area index LAI (estimated using a hemispherical camera). From satellite data, a profile of the normalized difference vegetation index (NDVI) was generated for each pixel. For both types of cereal, a relationship is established between NDVI and leaf area index LAI. This relationship is exponential and it allows connecting the satellite observations with a variable key biophysical functioning of plant canopies (LAI). The inversion of this relationship can provide estimation of leaf area index with spatialisation over the entire site.
The second axis of research concerns the estimation of the grain yield. The approach was tested against 27 fields, selected with a large range of sowing date as well as irrigation and fertilisation schedules. Based on grain yield measures on the test plots, a relationship is established between NDVI and grain yield for 19/02, 17/03, 05/04 and 28/04/2011 dates. The results show that earlier forecasts are possible from the mid-March to mid-April with approximately a root mean square error (RMSE) equal to 25.46kg/ha and an average yield equal to 280.5 kg/ha for test fields.
For the third axis, we used the SAFY model. It provides simulations of LAI, DAM time courses and GY space variations. The approach validated over test fields, offers the advantage of being quite simple, without requiring any data on agricultural practices (sowing, irrigation and fertilisation). This makes it very attractive for operational application at a regional scale.

Key-words: cereals prediction, optical satellite, SAFY