Simple and spatialize approach to optimize irrigation water and wheat yield in the semi-arid areas

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Abstract

Population growth and the associated increase in demand for food have led to an urgent need for efficient agricultural production monitoring systems. Furthermore, southern Mediterranean, water shortage is likely to be one of the main pressing problems, resulting from combined effects of alterations in the hydrological cycle, accelerated under climate change, and of the increase in water demands, especially for agriculture. The objective of this study is to develop a simple and spatialized approach, based on remote sensing data, to optimize water irrigation and grain production (dry matter DM and grain yield GY). The proposed model consists of calibrating the Leaf Area Index (LAI) and the harvest index HI (HI) between 0 and 1, and converting these values into the radiometric vegetation index (NDVI) and the net primary production (NPP) to estimate under real conditions and local availability water irrigation amount and cereal production. It has been shown that the value of 0.7 of NDVI is considered a suitable threshold for triggering irrigation in semi-arid areas. Otherwise, the proposed method proposes using the harvest index (HI) for partitioning the dry matter developed between straw and grain. Since the soil water is considered in this study, the final harvest index (HJ) is estimated from the maximal value of Normalized Difference Vegetation Index (NDVI). The proposed model has been validated and validated on both semi and arid regions (Houaz in Morocco and Kairouan in Tunisia). The obtained results showed a good agreement between observed and estimated DM and GY values. Average values of NDVI and RMSE are about 0.98 and 0.35 t/ha for DM and 0.98 and 0.35 t/ha for GY, respectively.

Materials and methods

Study area

Experimental data

Remote sensing data

Proposed approach

Model spatialization, R3 zone

Validation of the developed yield estimation method

Sowing date

Dry Matter, DM

Grain yield, GY

The obtained results show a good consistency between the simulated and observed yields for the Hawza (black circles) and field (grey squares) (Fig. 2). The Nash Sutcliffe efficiency was close to 1 and the RMSE values are low with comparison to the average observed yields. This encouraged us to validate the model during the 2012 and 2013 seasons.

Model spatialization, R3 zone

As conclusion of this work:

- The proposed approach is simple and spatialize; the interception and conversion coefficients are calculated by combining meteorological data, sum of temperature, Leaf Area Index (LAI) and a threshold stress coefficient for starting irrigation (\(K_{\text{irr}}\)).
- The test of this approach showed good performance:
  - At the field scale, in Morocco and Tunisia, RMSE values lower than 0.98 t/ha and 0.35 t/ha for DM and GY, respectively.
  - At the regional scale (R3 zone, 2860 ha) RMSE values are about 1.28 and 0.44 t/ha for DM and GY, respectively.
- The accuracy of the simple proposed approach is consistent with the performance of AquaCrop model (relatively complex).

References

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