Spatial Analysis of Weather-induced Annual and Decadal Average Yield Variability as Modeled by EPIC for Rain-fed Wheat in Europe

Nikolay Khabarov1*, Juraj Balkovič1,2, Erwin Schmid3, Alexander Schwartz1, Ligia B. Azevedo1, and Michael Obersteiner1

Abstract

In our analysis we evaluate the accuracy of near-term (decadal) average crop yield assessments as supported by the biophysical crop growth model EPIC1. A spatial assessment of averages and variability has clear practical implications for agricultural producers and investors concerned with an estimation of the basic stochastic characteristics of a crop yield distribution.

As a reliable weather projection for a time period of several years will apparently remain a challenge in the near future, we have employed the existing gridded datasets on historical weather as a best proxy for the current climate. Based on different weather inputs to EPIC, we analyzed the model runs (as implemented by IIASA and BOKU) for the rain-fed wheat for 1968-2007 employing AgGRID/GGCMII simulations that use harmonized inputs and assumptions (weather datasets: GRASP and Princeton).

Key Messages

Our analysis of the variability of historical ten-year yield averages in the past forty years as modeled by the EPIC model, shows that generally the ten-year average yield variability is less than 20% (max-min/average), whereas there are mid/low yielding areas with a higher ten-years average variability of 20-50%. The location of these spots of high variability differs between employed model/weather data setups.

Assuming that historical weather can be used as a proxy for the weather in the next ten years, these numbers indicate the accuracy of an EPIC-based assessment of a ten-year average yield. The modeled inter-annual yield variability differs greatly between model/weather data setups and might be considerable (up to 30% of a decadal average) even in productive regions.

The scale of disagreement between the modeled yields and even more the differences in their estimated stochastic properties call for an extensive ground-based model validation.

40-year Average Rain-fed Wheat Yield (1968-2007). Columns correspond to the model/weather data setups: (a) EPIC-IIASA/GRASP, (b) EPIC-BOKU/GRASP, and (c) EPIC-BOKU/Princeton. Discrepancies between model setups (a, b) e.g. Italy and weather datasets (b, c) e.g. Southern France are well visible.

Decadal Yield Variability (Max – Min)/Average of four 10-year averages within 1968-2007 corresponding to three model/weather data setups as on figures above. Spatial extent of high variability areas (more than 30% of decadal average) varies greatly by model. The EPIC-BOKU/GRASP map (b) presents the highest estimated variability.

Inter-annual Yield Variability - average absolute deviation (AAD) of the yield within decades 1988-97 (upper row below) and 1998-2007 (bottom row). AAD = \frac{1}{10} \sum_{t=1}^{10} \left| \text{yield}_t - \frac{1}{10} \sum_{k=1}^{10} \text{yield}_k \right|

There are visible differences in AAD between decades for every model, whereas EPIC-IIASA/GRASP (a) and EPIC-BOKU/GRASP (b) estimate respectively lowest and highest AAD.

This research was supported by the EU FP7 project ECONADAPT (Nr. 603906)

1 International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria; 2 Faculty of Natural Sciences, Comenius University, Bratislava, Slovak Republic; 3 Institute for Sustainable Economic Development, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria

* Contact e-mail: khabarov@iiasa.ac.at