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

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Abstract

In our analysis we evaluate the accuracy of near-term (decadal) average crop yield assessments as supported by the biophysical crop growth model EPIC[i]. 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/GGCMI[ii] simulations that use harmonized inputs and assumptions (weather datasets: GRASP and Princeton).

[i] http://epicapex.tamu.edu/epic/

[ii] http://www.agmip.org/ag-grid/ggcmi/

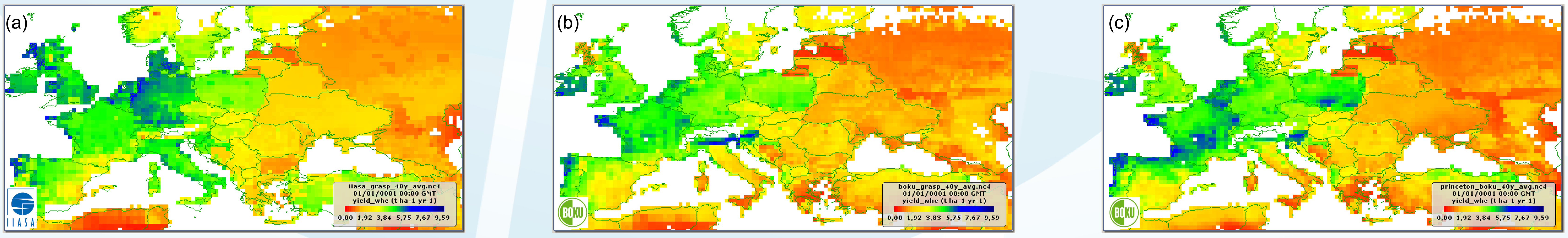
Key Messages

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.

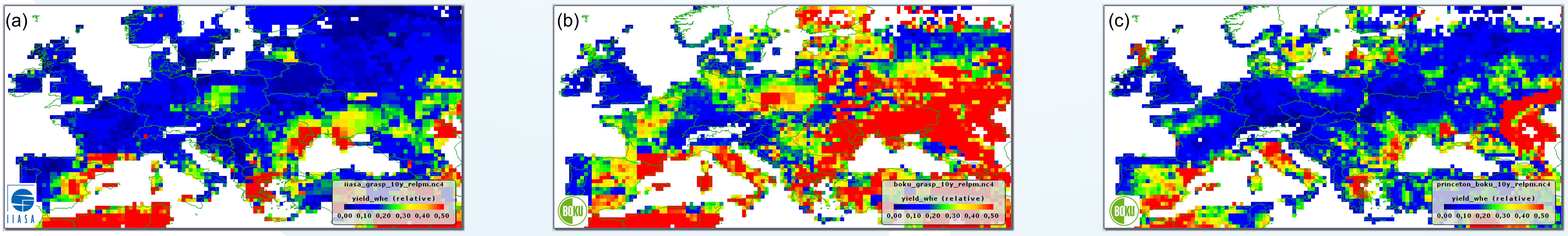
Assuming that historical weather can be used as a proxy for the weather in the next ten years, these numbers indicate the accuracy of an EPIC-based assessment of a ten-year average yield. The **modeled inter-annual yield variability** differs greatly between model/weather data setups and might be considerable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

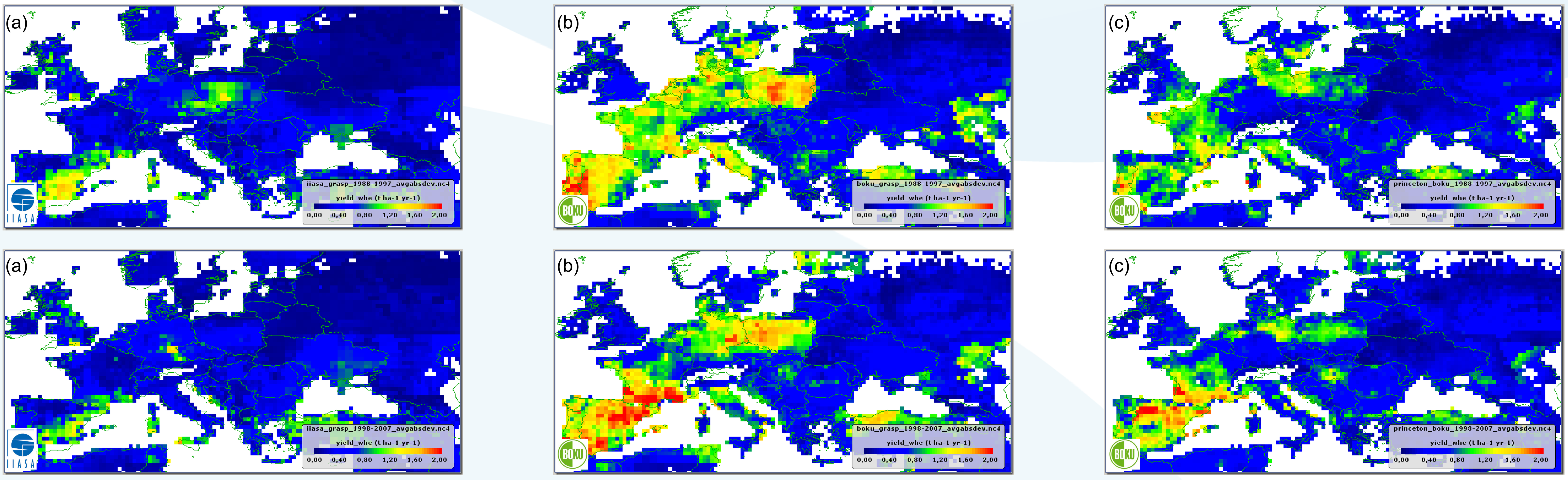
40-year Average Rain-fed Wheat Yield (1968-2007). Columns correspond to the model/weather data setups: (a) EPIC-IIASA/GRASP, (b) EPIC-BOKU/GRASP, and (c) EPIC-BOKU/Princeton. Discrepancies between model setups (a, b) e.g. Italy and weather datasets (b, c) e.g. Southern France are well visible.



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), $AAD = \frac{1}{10}\sum_{t=1..10}\left| yield_t - \frac{1}{10}\sum_{k=1..10} yield_k \right|$.
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.



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