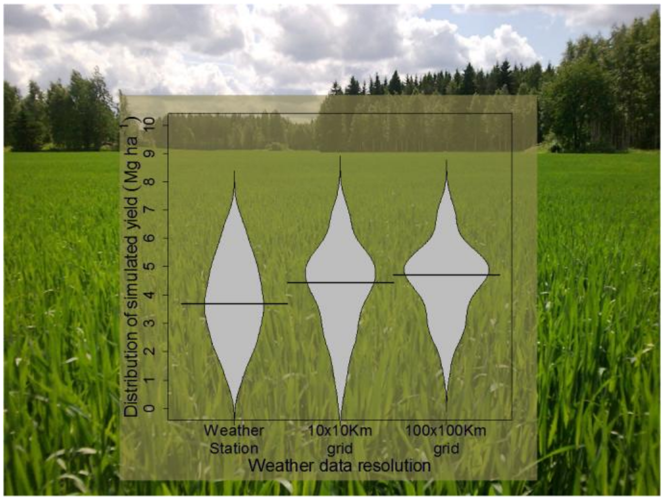

Characteristic 'fingerprints' of crop model responses to weather input data at different spatial resolutions

Carlos Angulo[a*], Reimund Rötter[b], Mirek Trnka[c,d], Nina Pirttioja[e], Thomas Gaiser[a], Petr Hlavinka[c,d], Frank Ewert[a]

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ABSTRACT

Given the adverse impacts of climate change on agricultural production, it becomes more and more important for the agricultural science community to generate reliable approaches to support policy decisions concerning food security at multiple scales. In this respect, mechanistic, plot-scale crop growth simulation models are frequently used tools for regionally assessing the effects of climate change and variability on crop yields. These models require spatially and temporally detailed, location-specific, environmental (weather and soil) and management data as inputs, which are often difficult to obtain consistently for larger regions. Aggregating the resolution of input data for crop model applications may increase the uncertainty of simulations to an extent that is not well understood. The present study aims to systematically analyse the effect of changes in the spatial resolution of weather input data on yields simulated by four crop models (LINTUL-SLIM, DSSAT-CSM, EPIC and WOFOST) which were utilized to test possible interactions between weather input data resolution and specific modelling approaches representing different degrees of complexity. The models were applied to simulate grain yield of spring barley in Finland for 12 years between 1994 and 2005 considering five spatial resolutions of daily weather data: weather station (point) and grid-based interpolated data at resolutions of 10 km × 10 km; 20 km × 20 km; 50 km × 50 km and 100 km × 100 km.

Our results show that the differences between models were larger than the effect of the chosen spatial resolution of weather data for the considered years and region. When displaying model results graphically, each model exhibits a characteristic 'fingerprint' of simulated yield frequency distributions. These characteristic distributions in response to the inter-annual weather variability were independent of the spatial resolution of weather input data. Further evaluation will be required to understand the robustness of a model's fingerprint across a larger range of conditions and the relationships to the underlying processes in order to better explain difference in fingerprints among models. In any case–, for depicting uncertainties caused by input data resolution and modelling approaches, it is more advantageous to evaluate model performance considering also the frequency distributions than to relying on selected summary statistics such as mean, median or standard deviation only.

Using one of the models (LINTUL-SLIM), we further analyzed how the aggregation strategy, i.e. aggregating model input versus model output data, influences the simulated yield frequency distribution. Results show that aggregating weather data has a smaller effect on the yield distribution than aggregating simulated yields which causes a deformation of the model fingerprint. We conclude that changes in the spatial resolution of weather input data introduce less uncertainty to the simulations than the use of different crop models but that more evaluation is required for other regions with a higher spatial heterogeneity in weather conditions, and for other input data related to soil and crop management to substantiate our findings.

According to our results, and in line with other studies, using not only one but different crop models should become a standard procedure when investigating the climate impacts on regional crop yields since it offers the possibility to accurately quantifying and report uncertainty and therefore better supporting decision makers.

Key words: Crop model, weather data resolution, aggregation, yield distribution

* Corresponding Author. Tel.: +49 228 73 20 47; fax: +49 228 73 28 70
Email: klav@uni-bonn.de (C.Angulo)
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