

Climate change impacts on agricultural yields in Hesse

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The aim of this study was to evaluate the impacts of a range of global greenhouse gas emission scenarios on the yields of important Hessian crops in a spatially resolved way. We used the temperature and precipitation data that were produced by the regional climate model REMO for a high (A1B) and a low (B1) global emission scenario. This climate information served as input to the crop production model DAYCENT which was applied to compute 30 year average changes of potential crop yields in the period 2041-2070 relative to the period 1971-2000. We estimated yield changes of wheat, barley, sugar beet, maize (silage) and rape.

For maize and rape as important crops for biofuel production we additionally computed the changes in frequency of severe yield losses during the future 30 year period compared to the period 1971-2000. Severe yield losses were defined here as a $> 15\%$ and $> 30\%$ yield reduction compared to the average yield of the period 1971-2000. These thresholds are similar to yield losses that were experienced during the extremely hot summer of 2003 on the German scale (-15%) and as a maximum for a federal state (-30%) for silage maize as well as rape (compared to the period 2000-2005).

The results of the study can be summarized as follows:

- Higher temperatures together with decreasing summer precipitation induce 30 year average changes of yields that vary considerably, both between crops and with respect to the spatial distribution of the severity of impacts on potential crop yields.
- Highest yield decreases were computed under the A1B scenario for rape in the north of Hesse. The highest yield increases were estimated under the B1 scenario for maize especially in agricultural areas at higher altitudes.
- An increasing number of years with severe yield losses was computed especially for rape but also for silage maize for the -15% threshold for the total of Hesse. The frequency of exceeding the 30% threshold on the Hessian scale was small in the past and will remain so under the given scenario assumptions. However, it is important to note here that we did not consider factors such as the climate-induced increasing spread of pests and diseases.

Adaptation options for crop production under climate change conditions have been extensively discussed during the last years. These options are numerous and vary widely e.g. with respect to the time and resources needed to realize them: From an expansion of irrigation areas to cope with decreasing summer precipitation, the breeding and introduction of new varieties to cope with new pests and diseases to educational and awareness raising measures to prepare the next generation of farmers for the upcoming (and partly already existing) challenges of changing climate conditions. To support the discussions and the planning process for adaptation measures it would, from a scientific perspective and due to the complexity of the climate system, be helpful to consider the range of uncertainty more reliably by using an appropriate ensemble of global climate models for impact assessments.