

# ASSESSING DIFFERENCES IN THE FARM LEVEL VULNERABILITY OF THE CEREAL PRODUCTION IN THE CENTRAL EUROPE – CONSEQUENCES, UNCERTAINTIES AND ADAPTATION OPTIONS

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## Abstract

Central Europe is located between East and South European climate change hot-spots where its impact is thought to become visible sooner or will be more pronounced (or both). Despite the fact that agriculture is by no means a dominant activity in the region it remains an essential part of economy (and landscape) and in most cases it is based on the performance of few crops as it is case of spring barley and winter wheat within the Central Europe. It is obvious that production stability and quality would be influenced under changed climatic conditions and that these changes will differ between regions and farms. However the magnitude of the change in crop production (both positive and negative) is not fully known due to the large differences between individual global circulation models (GCM) and SRES scenarios. In order to assess trends and magnitude of crop yields (and other production characteristics of two selected crops) we applied dynamic crop models CERES-Barley and CERES-Wheat. Both models were evaluated using data from 17 (7) experimental sites with 230 (87) experimental years as well as compared with statistical yield levels at the NUTS4 level (Fig. 1). The extensive experimental database was also used to verify whether the model correctly simulates differences in crop growth processes caused by varying farming techniques, climatic and soil conditions. In order to carry out spatial analysis, the model was run for all combinations of 125 weather stations using 400 soil pits using special software package: Marwin. The results were then interpolated into a 1x1 km grid matrix using ArcInfo GIS software and only grids covered by arable land were analyzed further. The selection of the model crops made possible to distinguish between climate change impact on the winter and summer crops. The resolution used in the study allowed to evaluate changes on the scale of large farm units (NUTS 4) for which the models were also validated and thus assess their vulnerability to the climate changes.

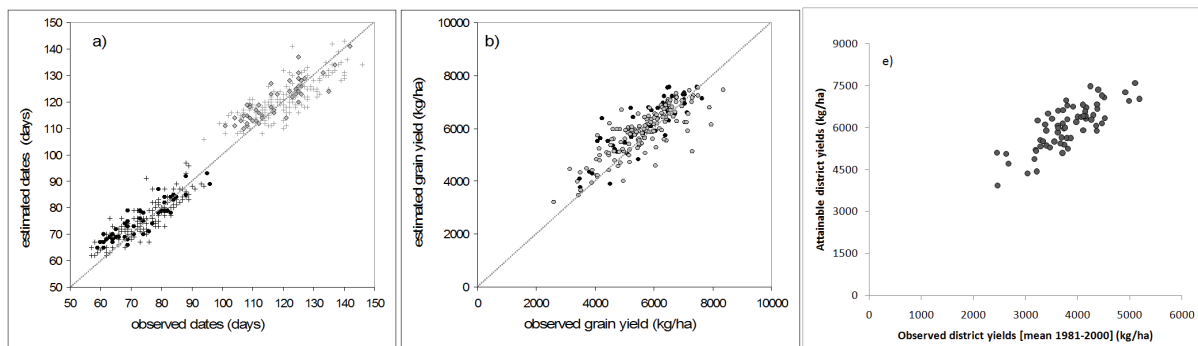


Fig. 1. Results of the calibration (a,b – darker color) and verification (a,b,c) of the anthesis and maturity (a); grain yield at individual experimental sites (b) and spatially integrated yields at NUTS4 level (c) of spring Barley.

In order to estimate the uncertainty in the future cereal production at this spatial scale number of GCMs provided for the Fourth Assessment Report (4AR) was used, namely ECHAM, HadCM and NCAR-PCM. The GCM based projections were based on the three SRES scenarios (i.e. A2, A1B and B1) taking into account three levels of climate system sensitivity (CS). The scenario values were used to set up boundary parameters of the future climate over the Czech Republic and part of Austria (including CO<sub>2</sub> levels required as an input for the crop model). In the next step synthetic weather

series of 99 years were generated for each of 125 weather stations and centered for time periods centered on years 2020, 2030, 2040, 2050 and 2100. In order to estimate future yields more realistically both long-term trends in grain production yields between 1918-2005 (accredited to technological advance) and effects of simple adaptation strategies were taken into account. The latter included optimization of fertilization and sowing dates, changing basic parameters of the cultivar and finally measures to increase soil water accumulation during winter that precede to sowing.

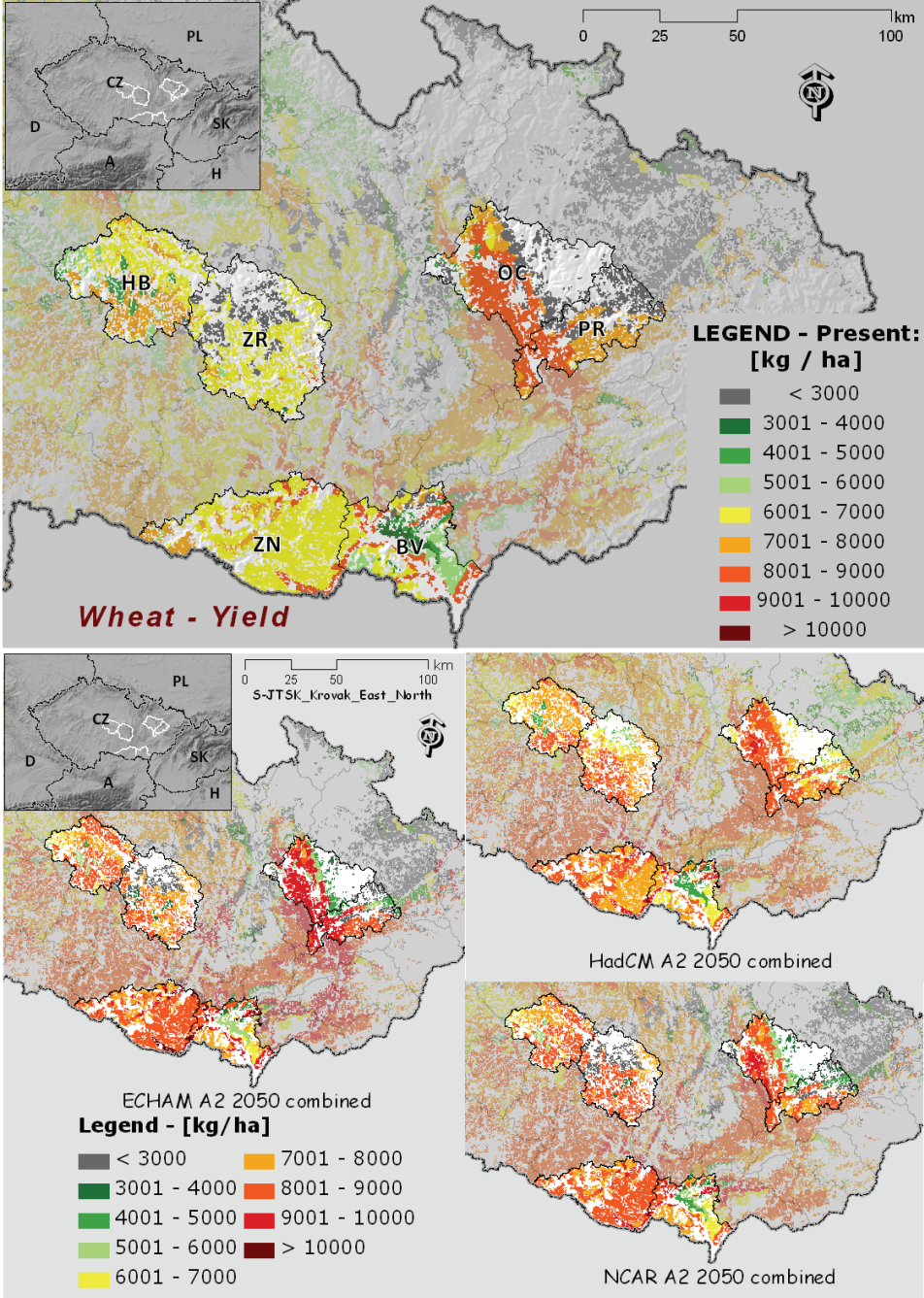


Fig. 2. Levels of the mean yield under present 1961-2000 climatic conditions (upper) and change of absolute mean yield (kg/ha) of winter wheat in 6 selected NUTS4 regions (bottom). The latter figure represents difference between present and expected yield levels according to three GCMs (as indicated in the legend) assuming high sensitivity of climate system and SRES A2 emission scenarios. Effects of both changed climate and increased CO2 levels are taken into account.

The result confirmed that both CERES-Barley and CERES-Wheat depicts well interannual variability of Central European spring barley and winter wheat production as e.g. the coefficient of determination between the simulated and experimental grain yields was higher than 0.70 at most sites and the

systematic bias was acceptable (Fig. 1). The range of uncertainty caused by the different projections within the set of used GCM is relatively large and is most pronounced in case of A2 SRES scenario in

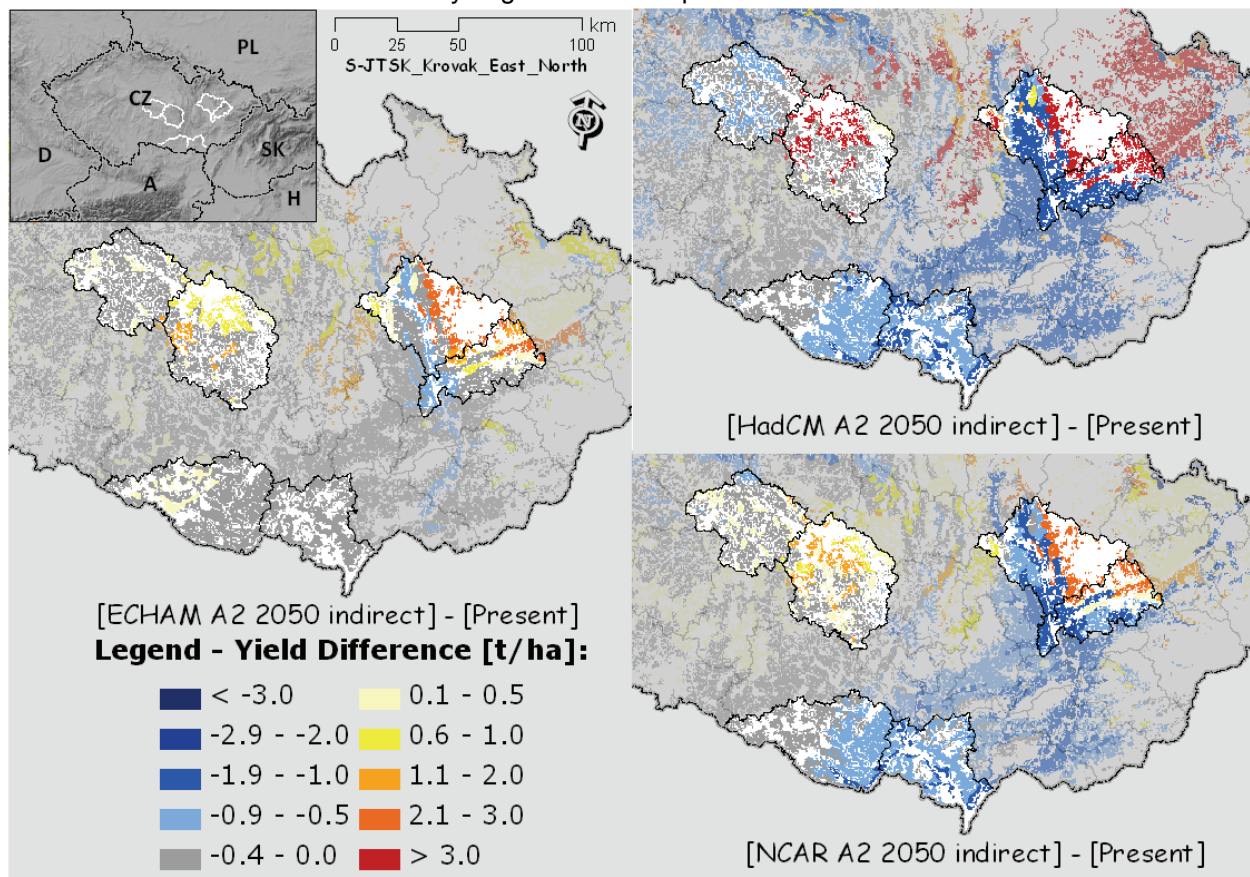


Fig. 3. Change of absolute mean yield (kg/ha) of winter wheat in 6 selected NUTS4 regions as a difference between present and expected yield levels according to three GCMs (as indicated in the legend) assuming high sensitivity of climate system and SRES A2 emission scenarios. Only change of climate conditions is considered.

combination with the high climate system sensitivity (Fig. 2, 3). In general yields are expected to increase across most productive areas in the target regions especially when positive CO<sub>2</sub> effect as estimated by CERES model is included (Fig. 2). However so called indirect effect of climate change (i.e. change of climate conditions without considering fertilization effect of CO<sub>2</sub>) is mostly negative especially due to increased water stress and reduced duration of growing season (Fig. 3). Overall uncertainty of the future crop productivity is rather high (larger than 20% between individual GCM for 2050) and becomes even higher in case of spring cereals (compared to winter cereals) as it is indicated at Fig. 2-3. The results suggest that the effect of GCM driven boundary conditions are dominant on the national level, whereas the future regional and farm level productivity is significantly influenced by relatively subtle differences in the abiotic conditions (e.g. present climate or soil conditions). However the effect of uncertainty within the available set of GCM-SRES-CS on the future national production levels is one order higher than then the effect of sub-regional differences.

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