

## 10.7 CLIMATE CHANGE IMPACTS ON SELECTED CROPS IN MARCHFELD, EASTERN AUSTRIA

Sabina Thaler\*, Josef Eitzinger  
Institute of Meteorology, University of Natural Resources and Applied Life Sciences, Vienna

Martin Dubrovsky  
Institute of Atmospheric Physics, Czech Academy of Sciences, Prague

Miroslav Trnka  
Institute of Agrosystems and Bioclimatology, Mendel University of Agriculture and Forestry Brno

### 1. INTRODUCTION

The Marchfeld region, located in the north-eastern (NE) part of the country, is one of the major field crop production areas but also one of the driest regions of Austria. It is a flat area (around 900 km<sup>2</sup>) with minor variations in elevation, ranging from 143 to 178 m. The region is influenced by a semi-arid climate: winters are usually cold with frequently strong frosts and limited snow cover, and summers are hot and intermittently dry (Müller 1993). The soil conditions are characterized by a significant spatial variability including soils with low to moderate water-storage capacity. Moreover, there is a very deep groundwater table (below 6 m depth) and hence no groundwater impact on the rooting zone (Eitzinger et al., 2003).

Higher temperature in next decades implies higher evaporation and therefore higher water demand for the crops. The phenological development rates of the crops will increase due to the higher temperature and an increase of heat stress as well as drought stress can be expected. These points influence mainly the water balance and the yield of the crops in the investigation area.

The main aim of this study was to determine the vulnerability of current agricultural cropping systems in the Marchfeld region to climate change.

### 2. MATERIAL AND METHODS

The digital Austrian Soil Map 1:25,000 indicates for the Marchfeld region more than 255 different soil types. This map includes data about soil profiles (down to 1 m depth), texture, pH, humus content etc. for each soil type. Using this data Murer et al. (2004) calculated permanent wilting point, field capacity, saturation point and plant available field capacity according to a transfer function method in *Bodenkundliche Kartieranleitung* (AG Boden, 1994).

To simplify the soil map, five soil classes by the amount of total available water capacity were distinguished (table 1), a crucial factor for plant growth. The soil classification was resumed; additionally average values for the physical and chemical soil properties weighed by the area of the soil types were calculated (Rischbeck, 2007). The first two soil classes - with an

available water capacity up to 140 mm - are mostly Parachernozems. They are classified as loamy sand and sandy loam soils, respectively. Soil classes 3 and 4 are medium Chernozems and Fluvisols, with an available water capacity between 140 until 300 mm (class 3: sandy loam, class 4: loamy silt). A colluvial Chernozem has the highest available water capacity with over 300 mm and is qualified as soil class 5. It is a light to medium soil and the high water-storage capacity is a result of the deep soil profile of 150 cm.

Classification	Available water capacity (mm)
very low	< 60
low	60-140
moderate	140-220
high	220-300
very high	> 300

Table 1: Classification of the capacity of available water of the mineral soils (AG Boden, 1994)

The DSSAT v4.02 model, designed to simulate the effects of cultivar, crop management, weather, soil water and nitrogen on crop growth, phenology as well as yield, was applied for this study to the main crops in the investigation area. The model required a minimum set of weather, soil, management and genetic data (Alexandrov et al., 2002). Management data for the experimental field Fuchsenbigl (lat. 48.322°, lon. 17.000°, elev. 149 m a.s.l.) was available from the Bundesanstalt für Pflanzenbau. Winter wheat cultivar "Capo", spring barley cultivar "Magda" and maize cultivar "Ribera" were selected; crops which currently grow on large acreages in Marchfeld. The DSSAT model was calibrated and validated for the three crops by using agrotechnological, phenological, yield and weather data.

The climate scenarios for NE Austria were performed with the global circulation models (GCMs) CSIRO, HadCM and ECHAM. Synthetic daily weather series of 100 consecutive years (input to crop growth models) were produced with stochastic weather generator (Met&Roll) (Dubrovsky, 1997) for present conditions (reference period 1961-1990) and 2050's. To account for the uncertainties six (3x2) scenario sets were defined (Dubrovsky et al., 2005):

- uncertainty in scenario pattern: 3 sets of GCMs
- uncertainty in the scaling factor: function of emission scenario and climate sensitivity. Hereby two versions of the scaling factor for a given period were used:

\*Corresponding author address: Sabina Thaler, Institute of Meteorology, University of Natural Resources and Applied Life Sciences, Peter-Jordan-Straße 82, 1190 Vienna, Austria; e-mail: Sabina.Thaler@boku.ac.at

- high climate sensitivity +4.5 K per doubling ambient CO<sub>2</sub>
- low climate sensitivity +1.5 K per doubling ambient CO<sub>2</sub>

A CO<sub>2</sub> concentration in the atmosphere of 360 ppm was assumed according the emission scenario A2 for present conditions, 535 ppm for 2050 (IPCC, 2001).

The simulated values of the climate scenarios contain the CO<sub>2</sub> fertilizing effect, adapted sowing date and contemporary crops without consideration of potential profit cuts caused by pest or diseases.

### 3. RESULTS

In figure 1 the change of temperature (in K) in respect to the present conditions for low and high climate sensitivity of the maximum and minimum temperature in Marchfeld until 2050 is presented. A clear seasonal trend of temperature increase can be noticed: the highest increases are in the winter months December and January (up to 4°C maximum temperature, 4.5°C minimum temperature) as well as the summer months July and August (up to 5°C maximum and minimum temperature HadCM high climate sensitivity). Lower increases can be expected in spring and autumn.

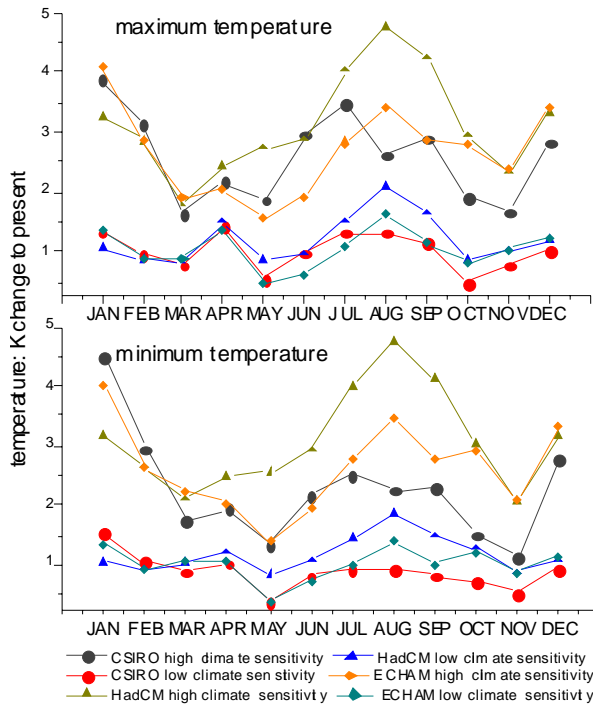


Figure 1: A2 SRES scenario 2050: CSIRO, HadCM, ECHAM – maximum and minimum temperature: K change in respect to the present conditions

For the selected study area, a decrease in the precipitation is predicted in spring and summer, but an increase in winter (figure 2).

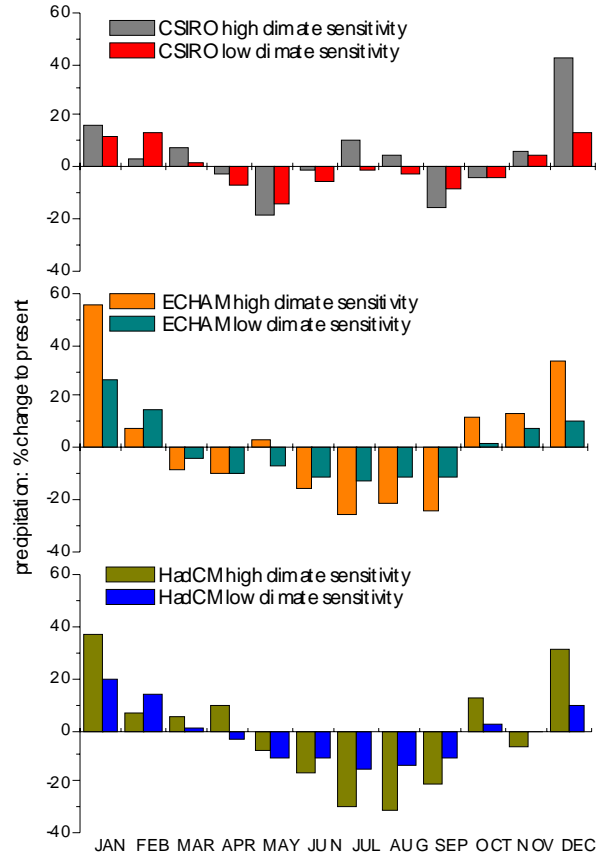


Figure 2: A2 SRES scenario 2050: CSIRO, HadCM, ECHAM – precipitation: % change in respect to the present conditions

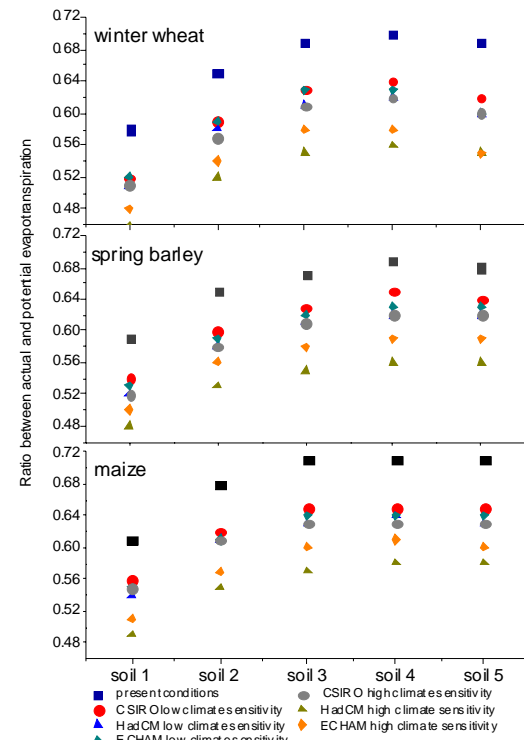


Figure 3: Ratio between actual and potential evapotranspiration on winter wheat, spring barley and maize fields (sum from seed to the next seed)

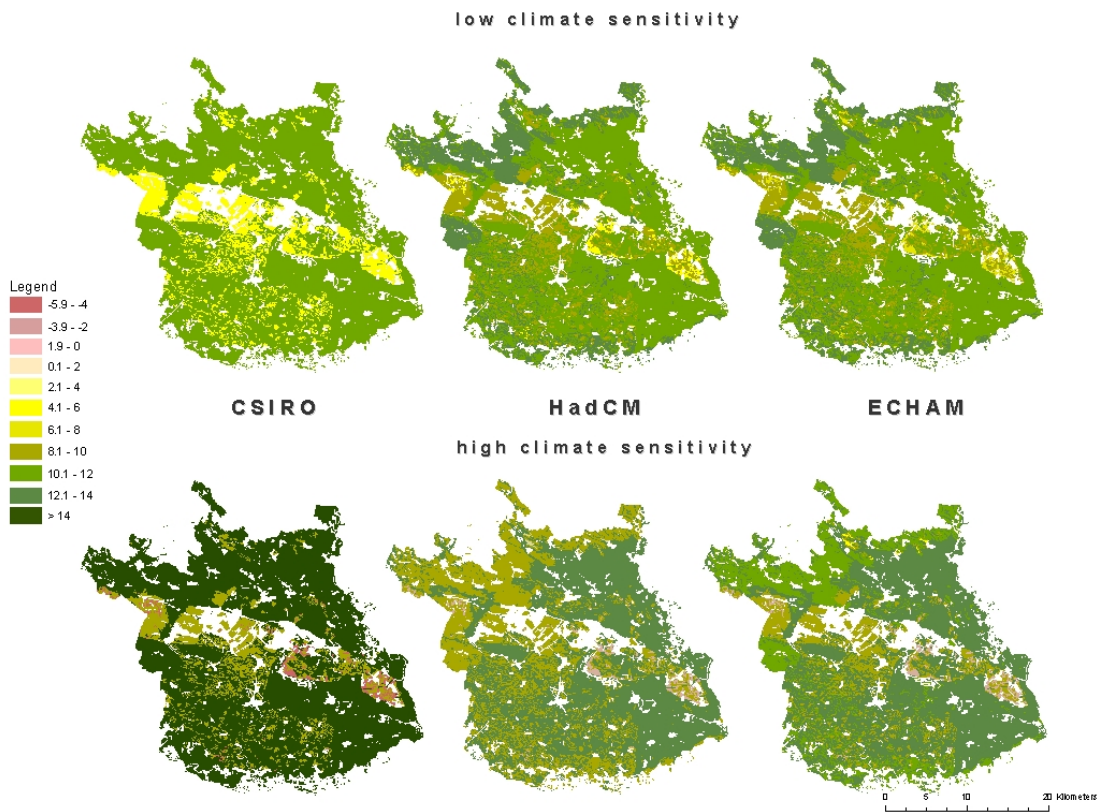


Figure 4: Relative change of the winter wheat yield to the present conditions for different GCMs in the investigation area Marchfeld – 2050

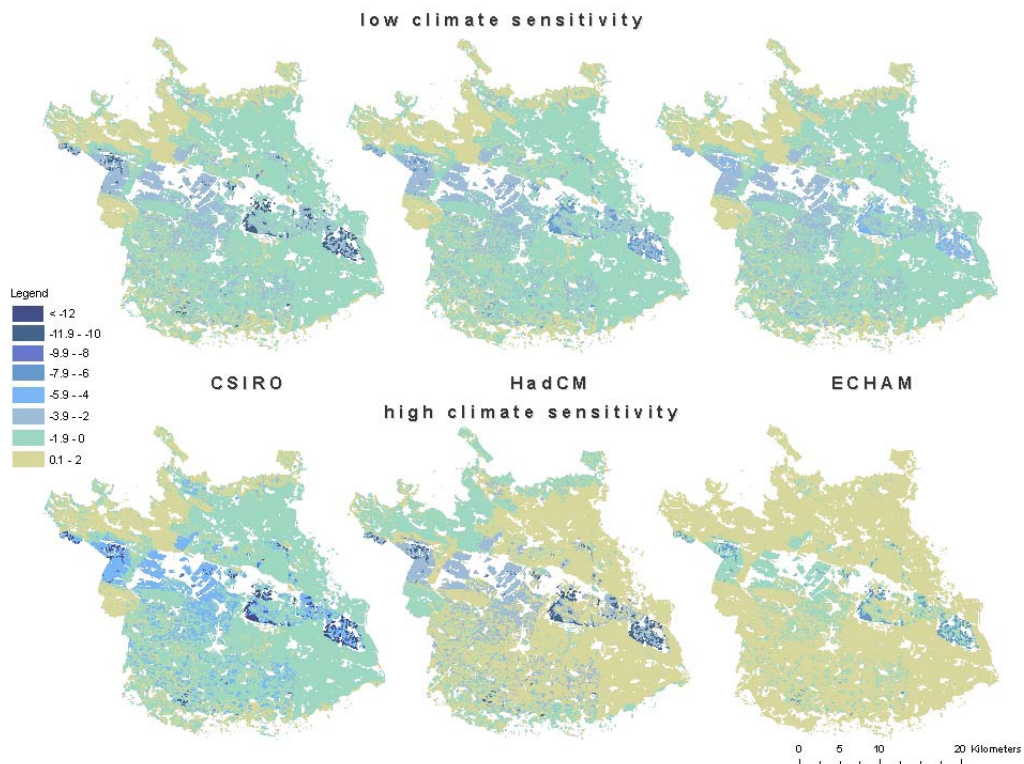


Figure 5: Relative change of the spring barley yield to the present conditions for different GCMs in the investigation area Marchfeld – 2050

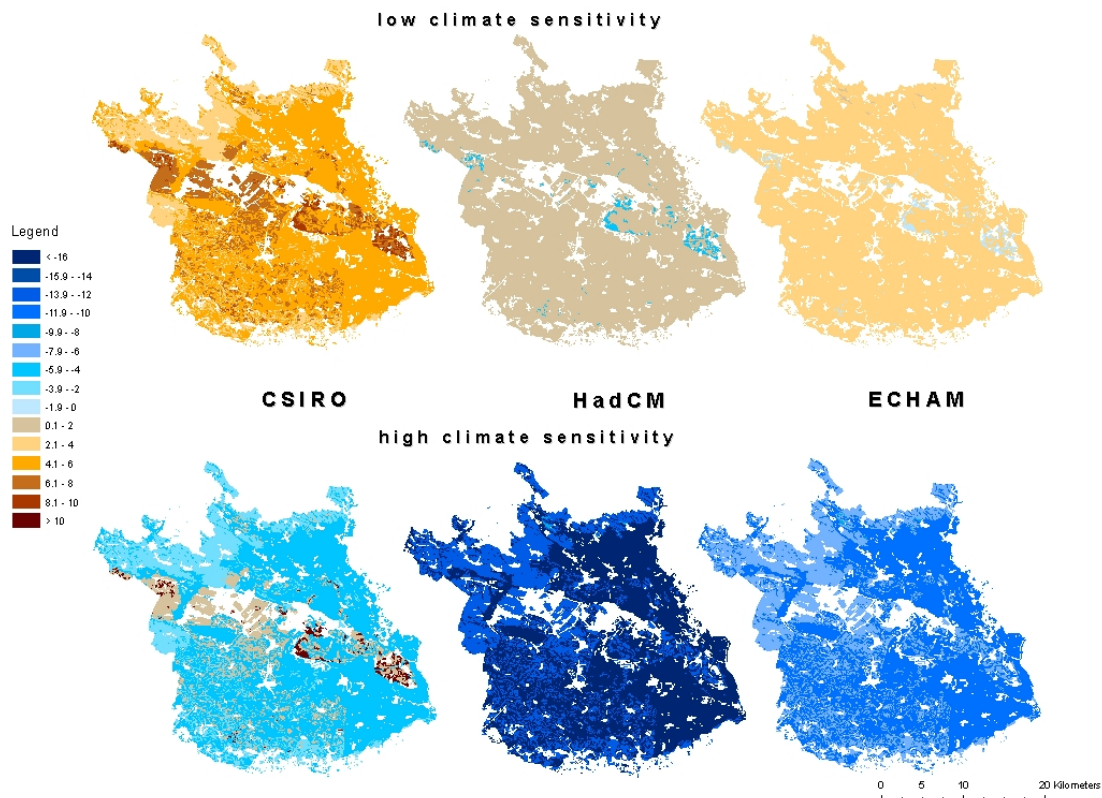


Figure 6: Relative change of the maize yield to the present conditions for different GCMs in the investigation area Marchfeld – 2050

The ratio between actual and potential evapotranspiration was used as a measure for plant drought stress. For all soil classes, a lower ratio (sum from seed to the next seed), which means a higher drought stress, was simulated (figure 3). The high climate sensitivity scenarios show the strongest effects; especially HadCM high climate sensitivity has an around 14% lower ratio on the maize and winter wheat field as well as 12% lower one on the spring barley field in respect to the present conditions.

A shift of average sowing dates is one strategy to adapt different cultivations in the Marchfeld region towards climate change. Climate change forces a delay of the sowing date of winter wheat of maximal 14 days in October (HadCM 2050 high climate sensitivity). In the case of spring barley and maize climate change allows an earlier sowing date in spring (8 days for HadCM/CSIRO 2050 high climate sensitivity) (automatic planting). An increase of winter wheat yield can be expected for soils with medium classified soil water storage capacity – up to 18% until 2050 (CSIRO high climate sensitivity). This is mainly a result of the simulated positive effect of enhanced CO<sub>2</sub> concentrations (considered as a maximum variant in the used model version, which is about 30% increase of photosynthesis for doubled CO<sub>2</sub> concentration) in the atmosphere on photosynthesis rate as well as the higher winter precipitation, which the crops can use. Soils with low soil water storage capacity instead reveal much lower yield increments or even yield losses (figure 4).

Spring barley and maize are more sensitive to climate change. Only on medium soils the spring barley yield might be maintained at the present level

around 2050 (HadCM/ECHAM high climate sensitivity), light soils, however, show yield decrements (figure 5). The low climate sensitivity models predict no change to small increase of the maize yield while the high climate sensitivity ones would lead to a decrease up to 16% (figure 6). Simultaneously, the interannual yield variability of both crops increases in all soils, leading to a higher economic risk for farmers.

#### 4. CONCLUSION

The Marchfeld region is one of the most important field crop production areas of Austria and is at the same time one of the driest regions. Higher temperatures and lower summer precipitation in the next decades imply higher water demand for the main crops in the area. Despite higher drought stress, winter wheat yields may increase due to compensation by higher CO<sub>2</sub> concentrations (except very light and shallow soils). However, if the CO<sub>2</sub> response of the crops would be less than assumed in the model, the yields could decrease significantly (figure 7). For spring barley and maize – being more sensitive to climate change (although for different reasons) - yield stagnations and decreases were simulated. A shift of the average sowing dates is one strategy to adapt crops in the Marchfeld region towards climate change.

In next step further strategies to adapt different cultivations in the Marchfeld region as well as regional climate change scenarios as model input will be studied.

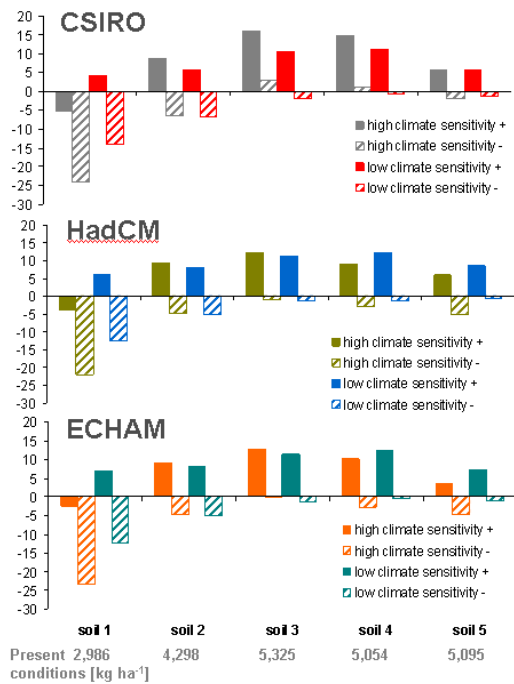


Figure 7: GCMs CSIRO, HadCM, ECHAM 2050: with (+) and without (-) CO<sub>2</sub> increase, Winter wheat, cultivar Capo (relative change of the yield to the present conditions)

## 5. ACKNOWLEDGMENTS

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