Selected aspects of climate change impacts on the landscape and agrosystems in the Czech Republic – *CASE STUDIES*

presented by: Miroslav Trnka

Institute for Agrosystems and Bioclimatology, Mendel University of Agriculture and Forestry Brno, Czech Republic, *mirek_trnka@yahoo.com*

TEAM MEMBERS – STUDY AUTHORS:

Assoc. Prof. Zdeněk Žalud, Ph.D.
Team leader,
impacts of climate change on crops and landscape

Martin Dubrovský, Ph.D.
developing climate change scenarios, weather generator Met&Roll, programming, stastics

Assistant Prof. Miroslav Trnka, Ph.D.
crop modeling, yield forecasting, drought assessment, pest&disease modelling

Assoc. Prof. Josef Eitzinger, Ph.D.
soil-plant-atmosphere relations, water&radiation balance

Daniela Semerádová, M.Sc.
Geographic Information Systems, Spatial Analysis, Database management

KONTAKT: mirek_trnka@yahoo.com
WWW: http://www.ufa.cas.cz/dub/crop/crop.htm#models

Examples of two specific climate change impact studies and risk assessments conducted during summer 2005 are given to illustrate the aims, methods and tolls of the research team.

CASE STUDY 1

Regional Drought Risk Under Expected Climatic Conditions

AIM: To determine drought risk in the selected region under present and changed climatic conditions using multiple meteorological drought indicators.

METHODOLOGY:

We have used so called relative Standardized Precipitation index (SPI), the Palmer Drought Severity Index (PDSI) or Palmer Z-index (PZI) described by (Dubrovský *et al.*, 2005). The core difference of this method over the original version is utilisation of the complete set of monthly data from all stations involved in the analysis as a reference data sequence. The presented study includes example of region-wide analysis of the drought risk in the Moravia&Silesia region.

The SPI, PDSI and Z-index characteristics were at first calculated at 96 stations within the region using the pooled monthly data from all stations during 1961-2000 as a reference. The results were interpolated using polynomial regression with easting, northing, elevation and Maximum soil water holding capacity as independent variables. The Digital Landscape Model (DLM) embedded in the GIS Arc Info platform with 1x1 km basic grid resolution was used for the construction of the final maps.

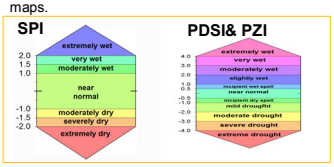

Figure 1: The threshold of the SPI, PDSI and PZI indices as provided by McKee et al. (1993) and Palmer (1965).

The applied climate change scenarios included three GCM (Echam4, HadCM3 NCARPCM) and three levels of climate system sensitivity in combination with defined SRES scenarios. Analyses were centered around the years 2010, 2020, 2030, 2040 and 2050 and 2080. For each climate change scenario the reference data set was modified by direct modification approach at each station

RESULTS:

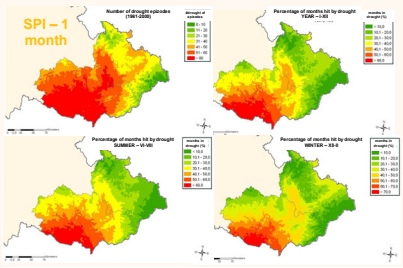

Figure 2: Spatial analysis of the relative SPI-1 month results under PRESENT CLIMATE (1961-2000) including number of drought episodes and percentage of dry months during whole year, summer (June-August) and winter (December-February) months.

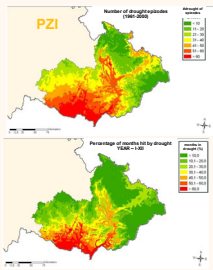

Figure 3: Spatial analysis of the relative Z index results under PRESENT CLIMATE (1961-2000) including number of drought episodes and percentage of dry months during whole year.

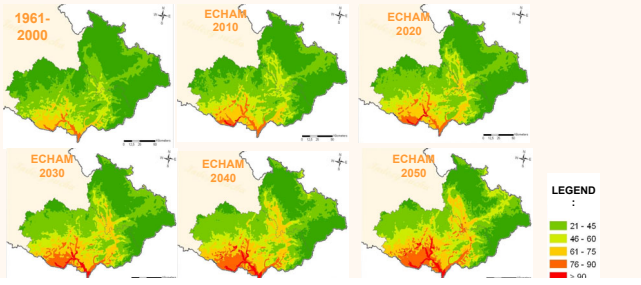

Figure 4: Spatial analysis of the percentage of dry months during whole year (based on relative Z-index) for the 1961-2000 baseline and EXPECTED climatic conditions in Moravia and Silesia. The climate change scenario is based on the ECHAM GCM model, average of A1 and B1 SRES scenarios and medium sensitivity of climate system to the greenhouse gasses concentration increase. The relative Z-index calculation used 1961-2000 baseline data as the reference. The area with drought probability < 20% is considered as "low risk", >60% "high risk" and "extremely high" >90 .

- Detail spatial analysis of SPI (Fig. 2) and Z-index (Fig. 3) under PRESENT climate shows marked area of higher drought risk in south-east of the country. This region is characterized by more than 60% of months being within a relative drought compared to the whole region. Both SPI and Z-index showed also that the mean drought episode duration is over 5 months.
- Spatial analysis of drought risk under expected climatic conditions (Fig. 4) shows that the marked increase of „high risk" area of the agricultural drought will become notable by 2020-2030 (depending on GCM scenario and climate system sensitivity used). By 2040 areas of extremely high drought risk (with 90% drought probability in 1961-2000 climate terms) will be established at south Moravia region and probably in the north-west of the Czech Republic (not shown) as well.

CASE STUDY 2

Possible Shifts in the Climatic Niche of European Corn Borer

AIM: To develop and evaluate the method of climatic mapping for determination of a climatic niche of European Corn Borer (ECB) under present and expected climatic conditions.

METHODOLOGY:

The Environmental Change Assessment Model for Ostrinia Nubilalis (ECAMON) that can be used in order to determine the extend of a climatic niche of the ECB under present and future climates (Fig. 5) was developed and provisionally programmed using VBA. Performance of the ECAMON was successfully verified using both multiple site data as well as set of 897 field observations from 234 locations during 1961-2000 period (Fig. 6 and Fig. 7). We have found e.g. that there is high degree of correlation between the climatic niche area (Figs. 6a, 7a) and the extend of actual damage caused by ECB (Figs. 6b, 7b).

Then we focused on the delimitation of the 1st generation climatic niche (i.e. area with climatic conditions suitable for complete development of the 1st generation in 75% of seasons – Fig. 8) and especially the 2 generation niche (defined as area allowing for complete two generation cycle in at least 66% of seasons-Fig. 9). The later one is particular important to the growers and the agrosystems as a whole because the second generation occurrence would increase loses to the maize yield and quality and thus would either lead to increase in the amount of insecticides applied or to Bt-hybrids (GMO) introduction.

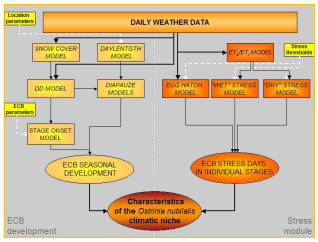

Figure 5: Simplified scheme of the ECAMON model modus.

The ECAMON was run at first at 45 representative sites with available daily data sets for 1961-2000 period. The results were then interpolated using polynomial regression with easting, northing, and elevation. The same DLM embedded in the GIS Arc Info platform as in the case study 1 was applied to derive the final maps.

We tested 12 climate change scenarios based on 4 GCM (Echam4, HadCM3 NCARPCM, CSIRO) and 3 levels of climate system sensitivity in combination with defined SRES scenarios. Analyses were centered around the years 2010, 2015, 2020, 2025, 2030, 2040, 2050.

RESULTS:

A) Spatial evaluation of the ECAMON performance under present conditions

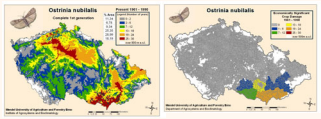

Fig. 6: The mean extent of the ECB 1st generation climatic niche during 1961-1990 (reference) period (a-left); reported crop damage with significant yield reduction caused by ECB during the same period (b-right).

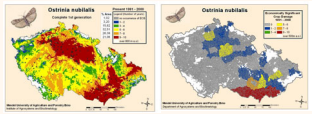

Fig. 7: The mean extent of the ECB 1st generation climatic niche during 1991-2000 (warmest decade of 20th century) period (a-left); reported crop damage with significant yield reduction caused by ECB during the same period (b-right).

B) Spatial distribution of the 1st generation

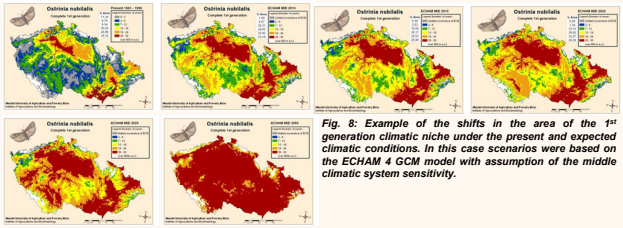

Fig. 8: Example of the shifts in the area of the 1st generation climatic niche under the present and expected climatic conditions. In this case scenarios were based on the ECHAM 4 GCM model with assumption of the middle climatic system sensitivity.

C) Spatial distribution of the 2nd generation

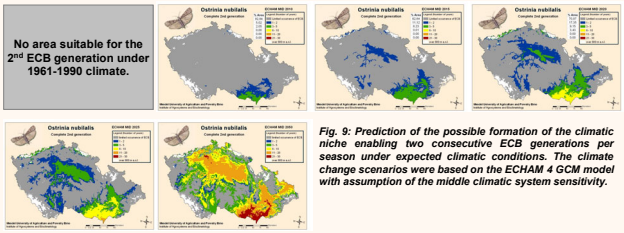

Fig. 9: Prediction of the possible formation of the climatic niche enabling two consecutive ECB generations per season under expected climatic conditions. The climate change scenarios were based on the ECHAM 4 GCM model with assumption of the middle climatic system sensitivity.

- The ECAMON estimates of the climatic niche correspond well with the reality and the method of climatic mapping proved to be efficient in case of ECB (Figs. 6-7).
- The trends under present conditions (1961-1990 vs. 1991-2000) are in accordance with expected climate change and were well depicted by the ECAMON (Figs. 6-7).
- Fulfillment of the scenario assumptions would lead to significant increase of the ECB 1st generation climatic niche from present 18% to 35-100% by 2050 (Fig. 8).
- Between years 2020-2050 (depending on the scenario) the main production areas will allow complete development of 2 ECB generations per year. The most pessimistic scenario predicts 40% of the country possibly hit in 2/3 of seasons by 2050 (Fig. 9).
- Similarly dramatic changes ought to be expected in case of other poikilothermic species.

References

Dubrovsky M., Trnka M., Svoboda M., Hayes M., Wilhite D., Zalud Z., Semeradova D., 2005: Drought Conditions in the Czech Republic in Present and Changed Climate. in: EGU 2005, Vienna, April 25-29 2005

McKee, T.B., Doesken, N.J., Kleist, J.: 1993, The relationship of drought frequency and duration to tome scales. Preprings, *Eight Conf. On Applied Climatology*, Anaheim, Amer. Meteor. Soc., 179-184

Palmer, W.C., 1965: Meteorological drought. Off. of Clim. Res. Pap., 45, U.S. Weather Bureau, 58 pp.

Acknowledgement:

I would like to thank to whole team working on both Case Studies for their support and to the Grant Agency of the Czech Republic (no. **521/03/D059**) for co-sponsoring the participation at the seminar. The poster was presented with the support of the AVEC summer school of 2005.