University of West Hungary
Faculty of Forestry,
Institute of Environmental and Earth Sciences, Sopron

Max-Planck-Institut für Meteorologie
Max Planck Institute for Meteorology

Climatic Role of Temperate Forests at the Forest/Steppe Limit

Borbála Gálos[1], Imre Berki[1], Áron Drüszler[1], Daniela Jacob[2], Csaba Mátyás[1]

[1] University of West Hungary, Institute of Environmental and Earth Sciences, Sopron, Hungary
[2] Max Planck Institute for Meteorology, Hamburg, Germany

contact: bgalos@emk.nyme.hu

Background

In the NEESPI Regional Focus Research Centre for Non-boreal Eastern Europe, Sopron, researches are focusing on the climatic tolerance and distribution of zonal tree species at the xeric forest limits (*Mátyás* et al. 2009). These limits at the planar border zone between closed forest and woodlands (forest steppe) are determined primarily by climatic aridity and are especially vulnerable.

In the last decade a direct link has been shown between recurrent summer droughts and health status of beech at their lower limit of distribution (*Berki* et al. 2009).

Not only the distribution of forests is determined and limited by climatic conditions, but also vegetation feeds back to the atmosphere.

Research efforts are focusing on following questions:

- What have been the climatic effects of land use change in the 20th century?
- Can increase or decrease of future forest cover alter the projected climate change signal?

Applied data and methods

Land cover databases

- for 1900:
  - 3rd Military Mapping Survey of Austria-Hungary,
  - Synoptic Forestry Map of Hungarian Kingdom (1895)
  - Database of Hungarian Central Statistical Office
- for 2000: CORINE 2000 land cover database

Land cover change scenarios for 2071-2100

- deforestation (forests replaced by grass)
- maximal afforestation (deciduous forests over the whole country)

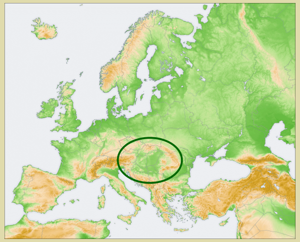

Figure 1. *Analysed region: Carpathian Basin*

Models

- MM5 NCAR/Penn State mesoscale meteorological model
- Regional climate model REMO (*Jacob* et al. 2001)
- Different land use change scenarios have been used as land cover input for MM5 (in 1900 and 2000) and REMO (for 2071-2100)

Climatic effects of land use change in the 20th century

Table 1. *Land cover change in Hungary (2000 vs. 1900)*

Land use type	1900	2000	Direction of the changes
Forest	12.50 %	21.07 %	↑
Urban	2.43 %	5.69 %	↑
Grassland	15.99 %	9.53 %	↓
Cropland	61.0 %	56.8 %	↓
Vineyard	2.49 %	1.51 %	↓
Water	2.26 %	1.86 %	↓
Wetland	3.22 %	1.12 %	↓

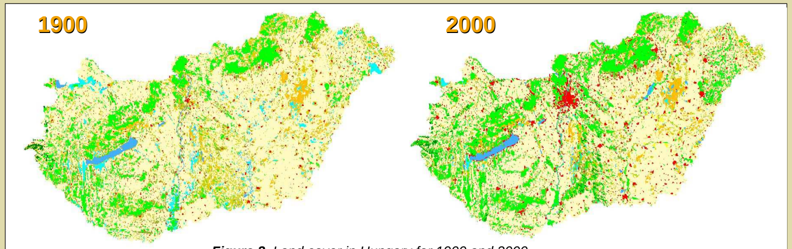

Figure 2. *Land cover in Hungary for 1900 and 2000*

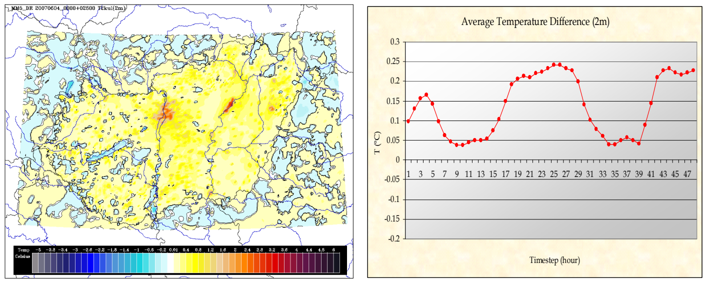

Figure 3. *Spatial distribution (left) and country mean (right) of temperature change in Hungary due to land use change (2000 vs. 1900)*

Feedbacks of forest cover change on climate for 2071-2100

- For 2071-2100, the projected rate of warming (*dT2m*) and drying (*dP*) of summer is the largest in the southwest part of the country (*figure 4*).

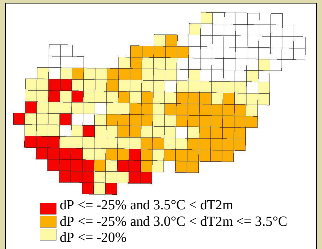

Figure 4. *Regions, affected the most by warming and drying (2071-2100 vs. 1961-1990)*

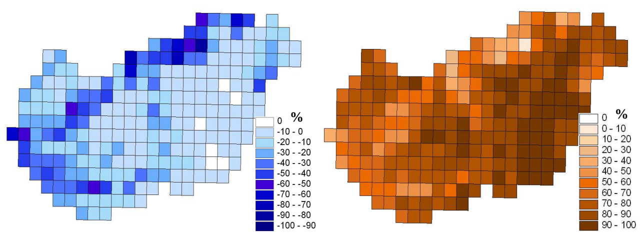

Figure 5. *Forest cover change for the deforestation (left) and maximal afforestation (right) scenario*

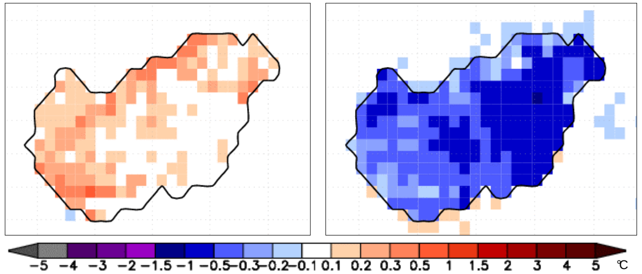

Figure 6. *Change of the 30-year summer mean of surface temperature for the deforestation (left) and maximal afforestation (right) scenario (Forest cover change experiment vs. reference land cover)*

Conclusions

- Climatic effects of land use changes are not negligible (especially on regional scale).
- Daily mean temperatures were 0.14°C higher in 2000 than in 1900 in Hungary.
- In urban areas (e.g. Budapest) the changes are more significant.
- If the whole forest cover is replaced by grass, surface temperatures are simulated to be higher, especially at the forest/steppe limit, which enhance the warming due to climate change
- Maximal afforestation results in lower surface temperatures due to the evaporative cooling effect, which can mitigate the projected climate change signal for the whole country.

References: Berki, I., E. Rasztovits, N. Móricz, Cs. Mátyás 2009. Determination of the drought tolerance limit of beech forests and forecasting their future distribution in Hungary. Cereal Research Communations vol. 37. ◆ Czúcz B., L. Gálhidy, Cs. Mátyás 2010. Limiting climating factors and potential future distribution of beech (*Fagus sylvatica* L.) and sessile oak (*Quercus petraea* (Mattuscha) Liebl.) forests near their low altitude - xeric limit in Central Europe. Ann. For. Sci (in press) ◆ Jacob, D, U. Andrae, G. Elgered, C. Fortelius, L. P. Graham, S.D. Jackson, U. Karstens, Chr. Koepken, R. Lindau, R. Podzun, B. Rockel, F. Rubel, H.B. Sass, R. N. D. Smith, B.J.J.M Van den Hurk, X. Yang 2001. A Comprehensive Model Intercomparison Study Investigating the Water Budget during the BALTEX-PIDCAP Period. Meteorol. Atmos. Phys. Vol. 77, Issue 1-4, 19-43 ◆ Mátyás, Cs, B. Fady G.G. Vendramin 2009. Forests at the limit: evolutionary – genetic consequences of environmental changes at the receding (xeric) edge of distribution. Report from a researcher workshop. Acta Silv. Lign. Hung. 5: 201-204