The role of soil in bioclimatology

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Abstract The role of soil in bioclimatology can be evaluated at different scales. At micro- and/or meso scale (in time: few hours; in area: small watersheds) let's take the considered subject the biometeorology. Both bioclimatology and biometeorology consider flora, fauna and the human population. In expecting soil's role, exchange processes related to vegetation are considered as well.

Soil affects exchange processes in the greatest extent via water movement, which is determined by the hydraulic properties of soil. Beside soil texture and the hydraulic parameters of soil, the land-use and the landscape heterogeneity are also important. These effects influence not only the near surface processes, but also the cumulus convection and the weather phenomena. The effects of soil hydraulic characteristics upon cloud formation were analyzed in Hungary too. It is proved that application of site-specific soil parameters is important especially at meso-γ scale (2-20 km).

The hydrological task of soil science is to specify as accurately as possible the infiltration at soil surface and the evapo-transpiration of soil-vegetation system. By the synergetic integration of water flow elements in the unsaturated soil zone the effect of climate and vegetation on time variation of soil water content in an oak forest is evaluated. In this study, the influence of plant stand upon microclimate under the leaf coverage is considered.

The effect of organic materials upon hydro-physical properties (water retention and hydraulic conductivity, K_s) of soil and the Scots pine forest is also studied. The litter cover effect can be indicated by the pattern of soil water content in artificial lakes opened in a beech forest. Another biotic effect on soil physical properties can be related to root growth and decomposition of fresh organic material.

The agricultural and environmental consequences of bioclimatically influenced soil physical properties can be analyzed by numerical modeling. The experiences obtained can also be applied at agricultural fields. It can be concluded that soils play important and deterministic role in both bioclimatology and biometeorology.

Introduction

Subject of bioclimatology according to the dictionary is to study the effects of climatic conditions on living organisms. In this context soil is the operational modifier of climatic conditions. However, this modifier function may act at different time and spatial scales depending on the type of exchange processes. Scales range from micro- (crop field), meso-scale (small watershed) to macro scale (great watershed to continent), and correspondingly the time ranges from few minutes, hours to few months, years. In bioclimatology the micro or meso-scale we distinguish as bio-, or agrometeorology. We try to outlay some modifier effects of soils and vegetation in bioclimatology and agrometeorology.

In bioclimatology soil's role comes from its border position between the lithosphere and atmosphere. Before anthropogenic change of the vegetation pattern of land, main vegetation formations were forests, grass fields, swamps, marshes, and deserts. However, agricultural plant production, forestry and animal husbandry have transformed the land pattern of the Earth. Expansion of plough areas, application of mineral fertilizers, amelioration and irrigation may cause climatic effects. Each of the mentioned agricultural activities has impact on the composition of atmosphere. In general, expansion of plough areas means *deforestation* both in temperate and tropical zones decreasing CO_2 fixation from the atmosphere. *Firings of vegetation* for cleaning up the area for agricultural use and plough them up increase again the amount of atmospheric CO_2.

Another consequence of changing the original vegetation into cultivated one is the change of land's albedo. For example 7 % albedo of the chernozem soil increases up to 25 % in the chernozem agricultural fields due to their lowered humus content, changed humus quality, and dryer soil conditions.

The 10 % higher reflection due to the *increased albedo* of soil would have to decrease air temperature with 1 C^o, but the increased glasshouse gas content of the air doesn't allow the reflected radiation outgoing to the Space. The use of 36 million ton of *mineral fertilizers* per year worldwide increases the concentration of nitrous compounds in the atmosphere. Nitrous gases function like greenhouse gases, and decrease the ozone concentration of the troposphere. Decreased ozone concentration however increases the ultraviolet irradiation of living organisms generating the shift of their former physiological regulation and balance.

These are the main bioclimatological consequences of changes of soil use pattern from natural to agricultural. Here we have to note that bioclimatic consequences of industrial use of lands as mines, pollution of lands with heavy metals and the use of other synthetic chemical compounds, the formation of mega policies (e.g. Tokyo, New York, etc) are not overviewed here.

In soil formation and development climatic effect as temperature and precipitation are considered the most deterministic among others. However, recently soil water is considered the most important factor of the existence and development of the terrestrial vegetation (Budagovsky, 1985). Gusev and Novak (2007) outlined a whole concept about soil water as the main resources for terrestrial ecosystems. Two main parts as surface and subsurface ones of soil water resources they differentiated. In general water supply of vegetation of a particular territory is related to the soil water content, and the concept of soil water resources doesn't figure at all as stated by Gusev and Novak (2007). From the continents 72,000 km^3 water evaporates annually (Sokolov, 1986). Of course a part of the evaporated water is evaporated from the surface of snow, ice, lakes, rivers, and water bodies not supposed to be soil water resources. However, this part is relatively small in comparison to the total amount of evaporation (Gusev and Novak, 2007).

Soil's role in plant's life is to supply water and nutrient elements for plants' growth and development. For the formation of dry biomass a plant really utilizes not more than 0,2 % of all water passing through it during transpiration (Vernadsky, 1960). From this follows the importance of water supply of plants from the soil.

Evaluation of the ratio between non-productive and productive evapotranspiration, and the problem of improving the structure of evapotranspiration is important (Budagovsky, 1985). In natural plant ecosystems forming multilayer polykind communities of plants the efficiency of water use is optimized, and the portion of nonproductive evaporation is substantially less than transpiration (Larher, 1978). Gusev and Novak (2007) derived evapotranspiration as measure of soil water resources. They stated that evapotranspiration (ET) is a more accurate characteristic of soil water resources than soil water content itself in the frostless period of the year. They introduced different aspects of soil water establishing that it is an element of the global climatic system since its location at the atmosphere-lithosphere interface, it notably contributes to the formation of climate. Even they formulated research directions as physics of soil water, the formation of soil water in large heterogeneous watersheds or region, which is connected to the interaction between the underlying soil-vegetation layer and the atmosphere. For modeling of that interaction Gusev and Novak (2007) constructed a Soil - Vegetation/snow cover – Atmosphere System (SVAS). In the SVAS soil plays one of the key roles with respect to the biosphere circulation structures. Soil's key role function originates from its control on transpiration rate by the dynamics of soil water storage (Gusev and Novak, 2007).

For demonstrating soil's role in physics of soil water, the interactions between the underlying surface and the atmosphere, and ecological and agricultural water management consequences of the formation of soil water balance case studies from our former research activity will be presented. Different land use forms and production intensity will also be demonstrated showing the greenhouse gas fixations and emissions. By a synergetic integration of water flow elements in the unsaturated soil zone the effect of climate and vegetation on time variation of soil water content in an oak forest will be evaluated. In this study, the influence of the plant stand on the microclimate under the leaf coverage of oak forest is analyzed. Vegetation types with different floristic composition are distinguished in the sessile oak forest (Standovár 1988, 1993). Links between water supply indication of herbs and the spatio-temporal behavior of soil moisture status are studied by comparing two vegetation types (Standovár and Rajkai, 1998).

Relationship between the climate and evapotranspiration, the effect of water holding capacity of soils on the climate are summarized in the work of Ács et al. (2005).

Soil acts not only on the near surface exchange processes, but also upon cumulus convection and so upon weather events as well. This is shown in the work of Horváth et al. (2006).

Soil's bioclimatic role in regulating the CO_2 turnover

Intensive agriculture uses up more energy of that is fixed in the produced plant biomass. Burning of fossil energy for soil and plant cultivation and transport of manure, fertilizer, sprayers, etc. increases the CO_2 and NO_X content of the atmosphere. There are many studies figuring out emissions of greenhouse gases by the agricultural plant production activity (e.g. Smith, et al, 1995). In Hungary such estimates for farms applying intensive, extensive and organic land use forms were studied and analyzed (Rajkai et al., 2007). In about 60 ha land of an intensive, extensive, and organic farm produced 13, 7, and 4 t CO_2 by using and burning fuels in 2001. The amount of fossil fuel was estimated from the fuel costs of the farms. However these farms fixed 30, 23 and 10 t CO_2 in the produced biomass between 2001 and 2005. The study demonstrates usability of the CO_2 fixation and emission estimation method at farm level. Former studies are available in regional scale e.g. for Canada and Australia (Smith et al., 2005; AMEGGES, 2005). Of course direct bioclimatic effect is not yet presentable.

Bioclimatic effects of irrigation of soils

Amelioration and irrigation as agricultural activity may cause agro-meteorological rather than bioclimatic effects. Drainage and water regulation of wetlands decreases free water surface, and increases albedo of the area. Irrigation has mostly short distance, and rather local effects, in spite that about 17 % of the agricultural area in the World is irrigated. It is shown that there is no detectable effect 10 m above irrigated fields, and 1 km far from water reservoirs (Moore and Ropstaczer, 2001). However, increased precipitations were statistically detectable in the neighborhood areas in the months of irrigations, which may indicate a possible bioclimatic effect of irrigation according to Moore and Ropstaczer (2001)

Soil's role in biometerorology and in formation of stand's climate

Soil reflects Sun's radiation. This is expressed usually by albedo. Soil's albedo depends on the color, roughness and water content at first, but all those properties depend on the particle-size distribution of the soil. Light texture soils have low humus and water content consequently their albedo is high. In spite that soils reflect back around one third of the irradiation energy some centimeters of the surface layer of soil can warm up above 60 Co. The high surface temperature of the light texture soils is the consequence of their low water content and heat conductivity. The daily high soil surface temperature drops down close to 0 Co in the nights. This daily temperature fluctuation generates a water transport from the deeper soil layers to the soil surface called vapor movement and dawn formation. That water redistribution has a group of specific biometeorological effects

in deserts and other dry land areas. Because of daily periodicity of temperature fluctuation of soil surface and the small amount of the redistributed water (80-90 mm annually), this phenomenon may have only biometeorological significance (Szász, 1967). However a meteorologist and an irrigation specialist questioned the dawn formation as effective additional water supply for plants (Bacsó, 1967; Ravasz, 1967).

Estimation of soil evaporation by meteorologists and soil scientists

Since bare soil evaporation has both agricultural and meteorological significance meteorologists calculate the effective evaporation (E) in Hungary as follows (Varga-Haszonits, 1977):

$$E = k \cdot \frac{W_0 + P}{\sqrt{1 + \frac{(W_0 + P)^2}{E_0}}} \qquad (1)$$

where, k is empirical constant. Its value for sand is 0,75, for loam is 0,85, and for clay is 0,65.
W_0 is the initial soil water amount in unit volume of soil (mm)
P is the precipitation (mm) in the studied time period
E_0 is the vapor pressure deficit of air (mm).

The equation (1) is the adaptation of the Turc method (Turc, 1958). The adaptation generated the k values for soils according to their texture in Hungary.

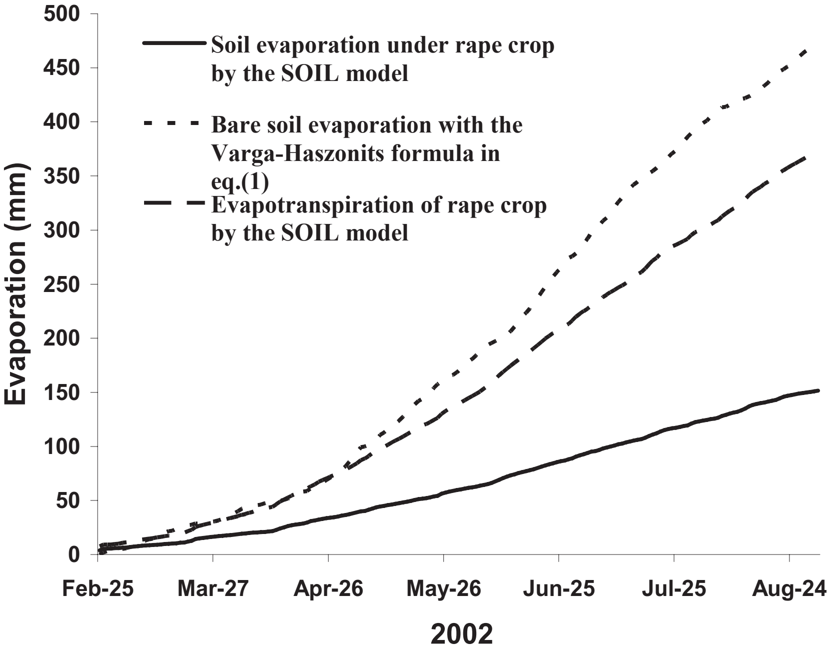

Figure 1. Evaporation from a bare surface and a rape cropped clay-loam soil in Ásványráró, 2002.

Bare soil evaporation depends on the both the meteorological parameters (air temperature, air moisture content, wind speed, etc.) and soil conditions (actual water content and temperature of the surface soil layer, water conductivity from the deeper soil layers, etc.). The example in Fig. 1 is from the Small Hungarian Plain at Mosonmagyaróvár. Bare soil evaporation is calculated by the eq. (1), and by the SOIL model considering initial water content and conductivity of soil layers and the meteorological parameters as global radiation, air temperature, air moisture content, precipitation and wind speed (Jansson, 1993). Evaporation calculated by the formula of meteorologists' eq. (1) is higher of that calculated with the SOIL model (Fig. 1). The difference is caused that soil evaporation under fully developed crop canopy coverage is about 10% of the canopy transpiration. The sum of soil evaporation during the time of plant growth is 40% of crop's transpiration. The amount of precipitation in the time of plant growth is less than the ET, so the soil became drier (Rajkai et al., 2006). Soil scientists calculate evaporation of bare soil either neglecting the vapor flow except at the soil surface, or including vapor flow when a definite drying front develops in the soil. When vapor flow is neglected soil evaporation is controlled by the liquid flow to the soil surface. This case is called the first stage of soil's drying. The second and third stage of drying both liquid and vapor flow must take into account, and must consider effects of temperature gradient on water movement. Campbell (1985) distinguished isothermal and thermally induced vapor flows. Using the SOIL-model both liquid and thermally induced vapor flow is considered since the water and heat transport functions are coupled in the model (Jansson, 1996).

The sensitivity of transpiration, E, characteristics to areal variations of soil properties is analyzed by Ács (2003a and 2003b). The used models are based on the *Penman-Monteith* concept. The transpiration characteristics are investigated in terms of analyzing the change of E versus soil moisture content, θ, relative frequency distribution of $E(\theta)$, and the algorithms for relating E obtained for a homogeneous and an inhomogeneous areal distribution of θ. The heterogeneity of soil characteristics is considered in terms of soil texture, areal variation of θ, and areal variation of soil hydraulic parameters (field capacity and wilting point soil moisture contents). In the study sand and clay soil textures are used. Transpiration characteristics seem to be most sensitive to the areal variation of θ. The E characteristics are sensitive to the changes of soil texture and areal variation of soil hydraulic parameters at about the same rate, though the characteristics of the sensitivity are different. The analysis is valid when there are no advective effects and mesoscale circulation patterns. The results obtained can be useful for estimating area-averaged transpiration.

Soil's biometerorological role in a Scots pine forest in the Hungarian Great Plains.

Gácsi (2000) analyzed the effects of organic materials on the hydro-physical properties (water retention and hydraulic conductivity, K_s) of soil.

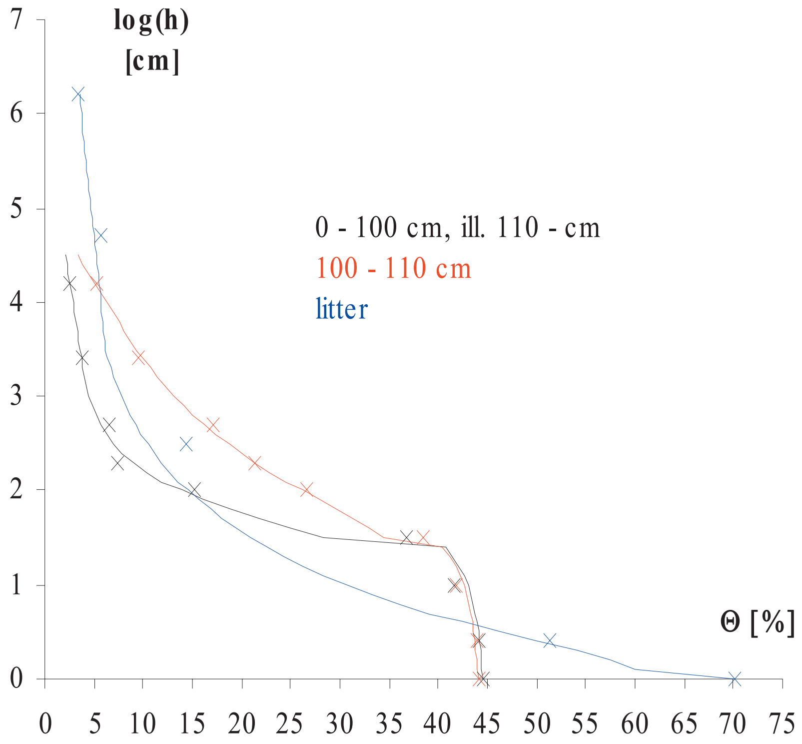

Figure 2. Water retention characteristics of soil layers and its litter cover in sandy soil.

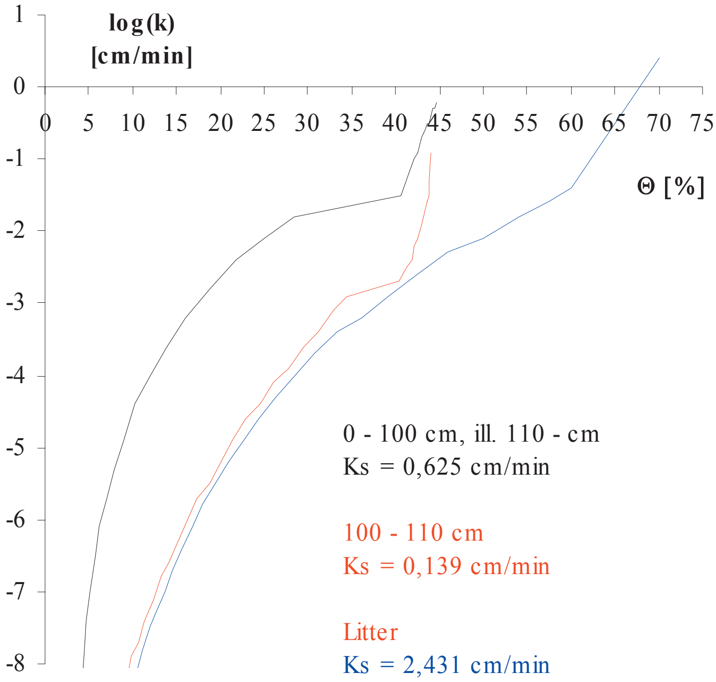

Figure 3. Water conductivity of sandy soil layers and the litter cover as a function of water content.

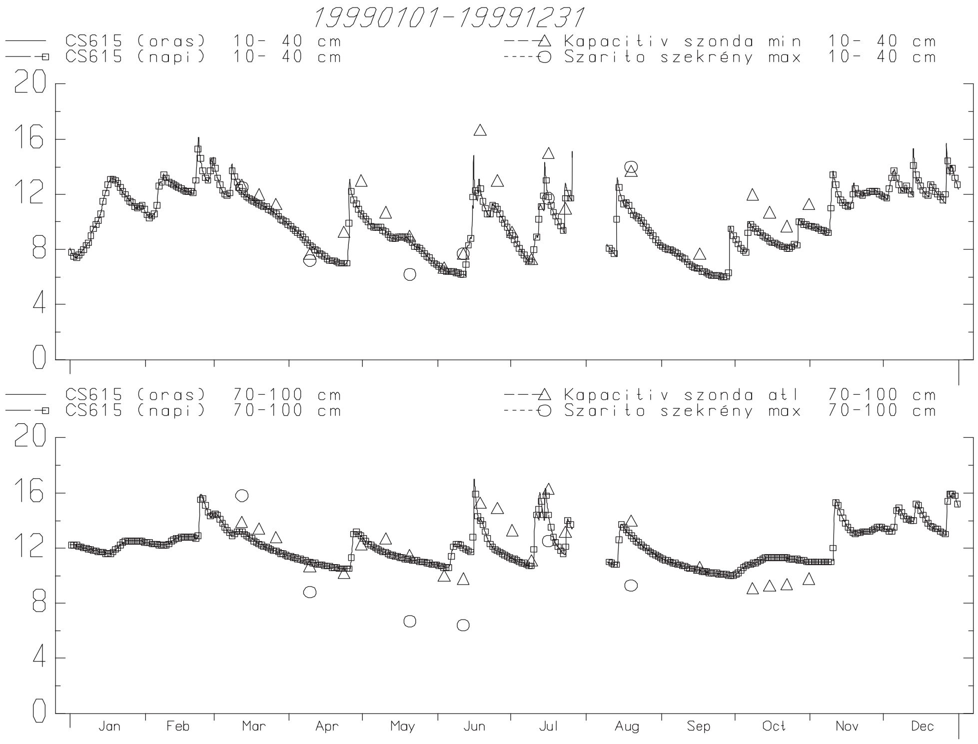

Figure 4. Water content time dynamics in two soil layers under a Scots pine forest in Bugac.

Litter carpet in a forest or mulch on an agricultural field decreases soil's evaporation and retains the water due to its water holding capacity as it is shown in Fig. 2.

Soil evaporation can be substantially reduced under the litter cover till its complete drying out. While soil evaporation is controlled by the litter cover water infiltration is not since water conductivity of the litter is higher than that of the soil in the entire moisture content range as it is shown in Fig. 3.

By the monitoring all meteorological elements of the study site in the Hungarian Great Plain between the Danube and Tisza rivers in the sand area the water balance elements can be calculated from the recorded soil water content data of soil layers (Fig. 4). Soil water contents were recorded with CS615 type moisture meters buried into different depths of the soil profile (Gácsi, 2000).

The water flow elements calculated from the soil water storage - calculated from the water content data - differences in the rainless periods and modeled with the SOIL-model are given in Table 1.

Table 1. Elements of water flow calculated from the soil water balance and simulated by the SOIL Model.

Elements of water flow	**Calculated**	**Modeled**
Change in soil water storage (10-130 cm)	-65 mm	-65 mm
Interception	95 mm	75 mm
ET	280-320 mm	305 mm
Deep drainage	150 mm	169 mm
For out of vegetation period		
ET	30 mm	35 mm
Fot the whole 1999 year		
ET	310-350 mm	340 mm
Evaporation	100 mm	106 mm
Transpiration	210-250 mm	234 mm

Stand climate of a Sessile Oak forest in the Bükk mountains.

Table 2. Soil parameters of the moist and dry sites in the Sessile Oak stand in Völgyfő.

Soil Layer cm	Water conductvity cm·day^{-1}		Parameters of the Van Genuchten function			
	K_{sm}	K_s	θ_s	θ_r	α	n
Moist site						
0-40	54	12	60.7	0.2	0.007	1.52
40-70	290	43	48.5	12.7	0.007	1.52
Dry site						
0-10	605	82	60.6	0.12	0.007	1.52
10-40	375	98	48.5	0.22	0.007	1.52

From Table 1 bare soil evaporation of the Scots pine forest stand is 130 mm while the complete evaporation is between 310 and 340 mm. This result was generated in a year when 312 mm rainfall was measured above the tree canopy within March 1., and Oct. 31. 80% of the precipitation fell through the tree canopy and reached the soil surface. 95 mm of intercepted water evaporated from the tree foliage. In this study almost each hydrological element of the Scots pine stand was possible to quantify directly or indirectly.

The links between site moisture status and moisture indication of herbaceous species were studied in a pure, even-aged sessile oak stand of 5.5 ha. Precipitation, air temperature, soil water content time dynamics, hydrophysical, and soil characteristics were measured and determined at the two different – drier and wetter, denser and sparser vegetated - forest sites. The deeper soil at the moist site contained about 21% ($g \cdot g^{-1}$) stone in the 0-40 cm while the 40-70 cm at the moist site and 0-10 cm of the dry site stone content was 35% ($g \cdot g^{-1}$) identically. The soil water storing capacity of the 0-70 cm soil layer at moist site is 240 mm, but of the 0-40 cm at the dry site is 110 mm. The available water for the vegetation is more limited at the dry site. Soil data and hydro-physical soil parameter values are given in Table 1. Inverse modeling was used to estimate the stand's climate at the two forest sites (Rajkai and Standovár, 2006).

Table 3. Site forest stand characteristics estimated by inverse modeling using the SOIL-model.

Meteorological and soil parameters	**Moist site with deeper soil**	**Dry site with shallow soil**
	1. Nov.-1. Apr.	1. Nov.- 1. Apr.
Shading Humidity Soil coverage	0,6 60 0,1	0,4 50 0,3
	1. Apr.- 10. May.	1. Apr.- 20. May.
Shading Humidity Soil coverage	0,8 80 0,2	0,6 60 0,6
	11. May.- 1 .Jun	21. May. –31. Oct.
Shading Humidity Soil coverage	0,9 85 0,7	0,6 60 0,6

Modeling results are shown in Table 3. Shading means the ratio of insolation reaching the soil at the study site within the forest. According to the obtained values 40% and 60% of the insolation reaches the moist and the dry sites out of the vegetation period. Shading increases with the development of foliage and insolation decreases to 20% and 40% at the moist and dry sites till mid May. In the summer the amount of light decreases to 10% under the dense vegetation cover at the moist site. The air humidity is significantly higher under the dense foliage, which reduces the evaporation from the soil surface and foliage of the herb layer. Soil coverage integrates all environmental factors affecting water infiltration to the soil. High soil coverage value e.g. 0.6 expresses the coverage of vegetation diverting water falling through the tree foliage, the steep slope position generating surface and subsurface runoff.

Simulated ETs at the two different forest sites are given in Figure 5. The dense vegetation at the moist site evaporates more than the sparse vegetation at the dry site. The dry site character is caused by the limited water storage of the shallow and high stone content soil. The extreme water regime of the shallow and high stone content soil is demonstrated well by the simulated soil water potential time dynamism (Fig. 6). The results of inverse modeling are based on model fit to the measured soil water content data shown in Figure 7.

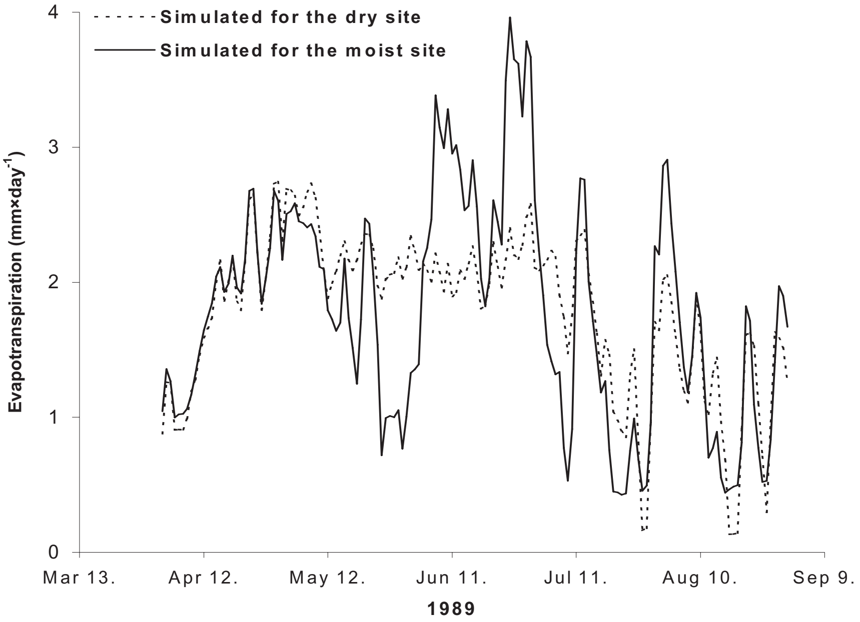

Figure 5. Simulated evapotranspiration time dynamics for the moist and dry forest sites.

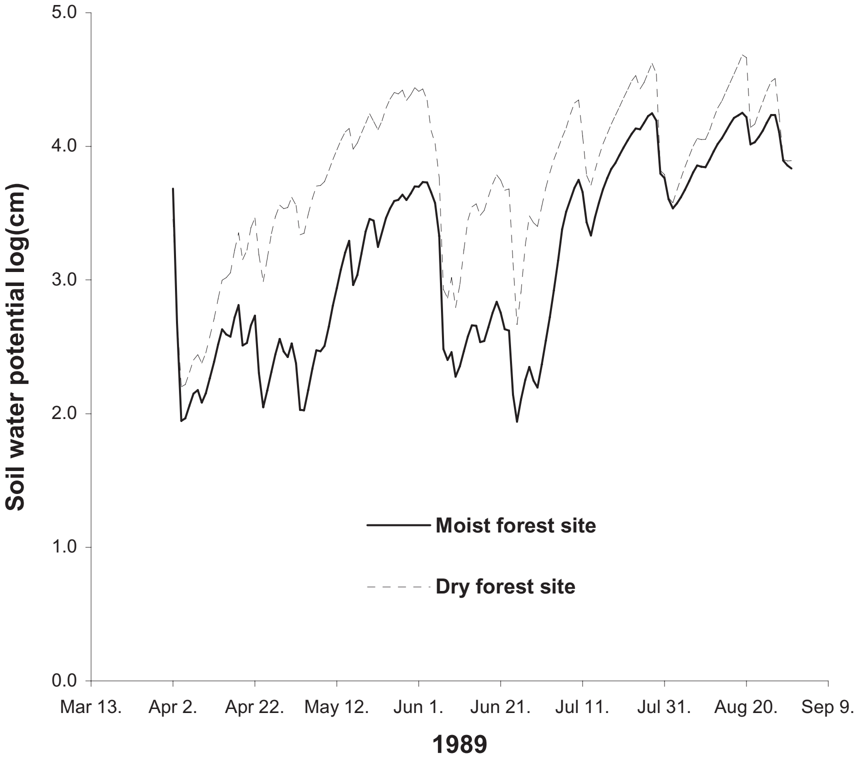

Figure 6. Simulated soil water potential time dynamism of the moist and dry forest sites.

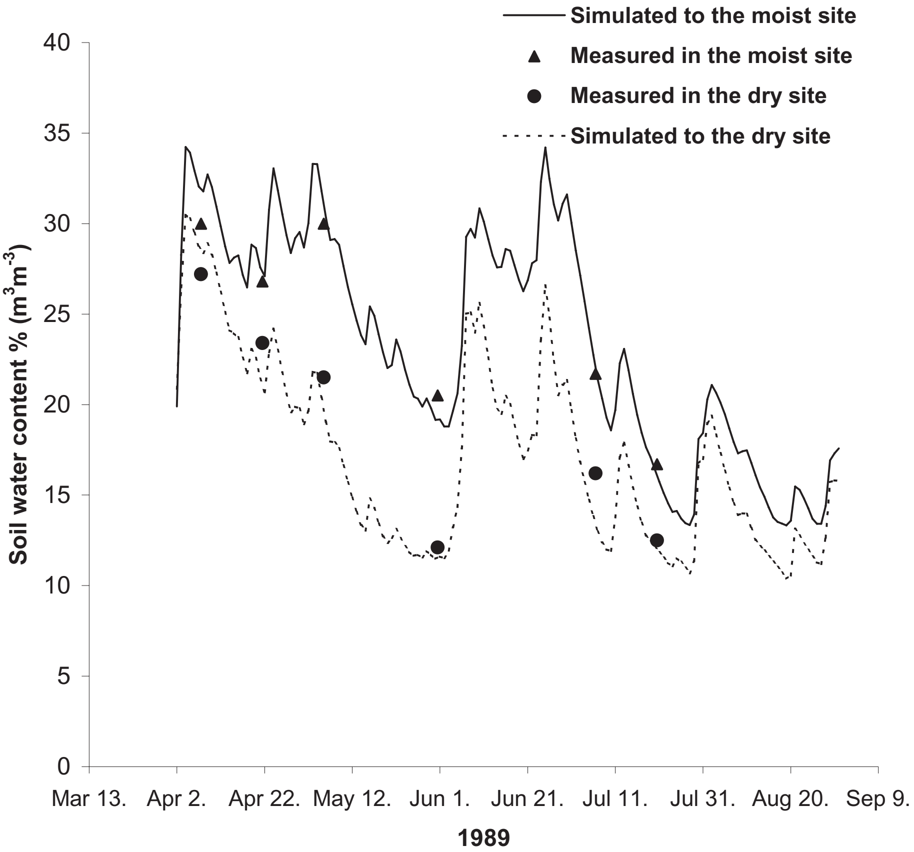

Figure 7. Simulated and measured soil water contents of the moist and dry forest sites.

Litter cover of soil surface can considerably modify K_s. Litter carpet of a forest decreases soil's evaporation and retains the water due to its high water holding capacity. Distribution pattern of soil water content in different diameter gaps in a beech forest were studied (Hagyó and Rajkai, 2005). The moisture pattern of the surface soil layer in the gaps demonstrated the canopy and litter cover effects compared to the moisture distribution under the closed canopy. Another biotic effect as root growth and decomposition like fresh organic material on soil physical properties can be connected to time variation of soil bulk density and water conductivity. Consequently the microclimate in the forest gap is significantly different from that under the closed canopy of the forest. The difference gives suitable environment for tree regenerations.

Relationship between soil water status and local climate

Ács et al., (2005) studied soils' impact upon climate by a Thornthwaite-based biogeochemical model assuming equilibrium between climate, vegetation and soil. The analysis was performed on both global and local (Hungary) scale. Global scale dataset is containing data of 230 meteorological stations referring to the whole Earth, while local scale dataset is containing data of 125 meteorological stations referring to Hungary. Climate data consists of monthly precipitation and temperature data. The climate as output is expressed via Thornthwaite's climate formula. Soil data consists of soil texture data and the corresponding hydro-physical parameters: the field capacity and wilting point soil moisture content. Soil texture on global scale was taken from the work of Zobler (1986), while on the local scale for Hungary a soil dataset of the GIS Laboratory of the RISSAC based on the work of Várallyay et al. (1980) was used. They distinguished five soil texture categories and three water holding capacity categories. They are as follows: 1) constant 100 mm water holding capacity; 2) water holding capacity is dependent upon soil texture and calculated using Clapp and Hornberger`s (1978) parameterization and Cosby (1984) parameter values (on global scale) and 3) water holding capacity is dependent upon soil texture but van Genuchten`s parameterization and Nemes (2003) parameter values are used for calculating hydro-physical parameters (on local scale for Hungary).

They showed that water holding capacity is a basic soil parameter, since changes in this parameter modify not only the fluxes of water vapor and carbon dioxide, but influence the climate on both global and local scales. They obtained different water holding capacity values, since the wilting point value is uniform all over the World, but field capacity is variable between pF=1.7 and pF=2.5. Here we use only results which refer to water holding capacity values obtained from conditions pF=2.5 – pF=4.2.

Their analysis indicated an unequivocal relationship between the areal distribution of annual climatic characteristics, evapotranspiration and soil respiration. We present here only that map which shows actual evapotranspiration for Hungary.

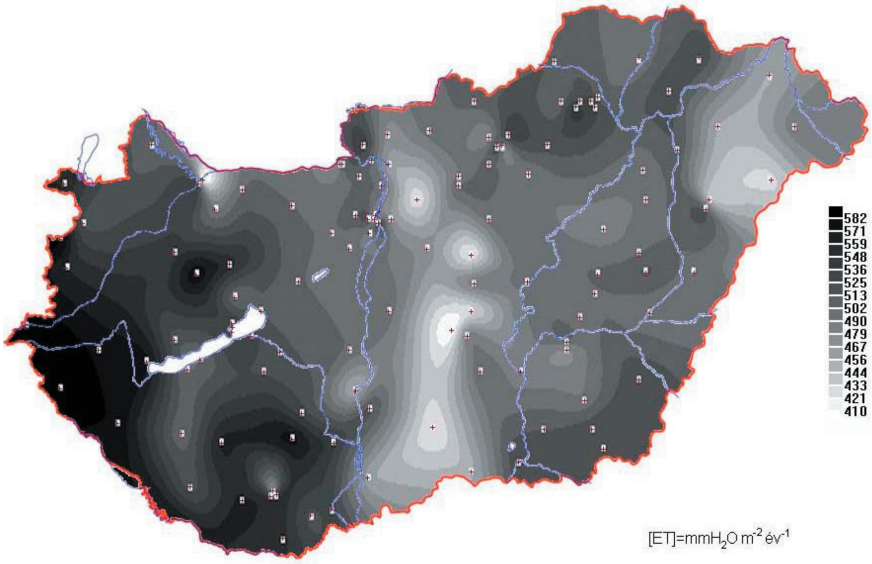

Figure 8. Areal distribution of actual evapotranspiration in Hungary using a Thornthwaite-based biogeochemical model.

Soil's impact upon storm formation and development: A case study

Numerical weather model simulations show that site specific soil hydraulic properties have profound impact upon storm processes. This sensitivity of storms to soil parameters is eye-catching at meso-γ scale (2-20 km) (Horváth et al., 2006).

Rising bubbles of hot air, called as thermals, form cumulus clouds in a relatively stable air mass. Rising of thermals in an unstable atmosphere generate thunderstorms, which produce heavy rain and hail accompanied by lightning, thunder and gusty winds. The sensitivity of formation and development of convective clouds to soil texture is investigated by numerical simulations. Land-surface effects on cloud formation are well known in meteorology. Pielke (2001) discussed and showed the sensitivity of cumulus convective rainfall to the land-surface energy and moisture budgets. The energy and moisture budgets of land-surface are determined by both the land use and hydraulic properties of the soil-vegetation systems as it is shown by Ács, et al., (2005).

A convective storm event occurred on 18th April, 2005. in North-East part of Hungary (in vicinity of Tiszaroff settlement) was investigated using both the USA and Hungarian soil data in the Penn State-NCAR MM5 Modeling System (Fifth-generation Mesoscale Model) (Dudhia, 1993). The results obtained are also compared to the accumulated surface precipitation data. The predictive variables of the model are: pressure perturbation, three momentum components, temperature, specific humidity and mixing ratios of the different type of hydrometeors (cloud water, cloud ice, rain, snow and graupel particles). For this study, the model is integrated with horizontal resolution of 6 km, and with 26 vertical levels. The system of partial differential equations is solved using relaxation lateral, and radiation upper boundary conditions.

The Oregon State University Land-surface Model (OSU LSM) was used to simulate land-surface processes. The model is based on coupling of Penman's potential evaporation approach (Penman, 1948) modified by atmospheric stratification effect (Mahrt and Ek, 1984), the multi-layer soil model (Mahrt and Pan, 1984) and the single-layer canopy model (Pan and Mahrt, 1987). Actual evapotranspiration is simulated by using the so-called β-approach based on the moisture availability concept (Horváth et al., 2006). Canopy resistance is formulated after Jarvis (1976) using relative stomata conductivity formulae of Noilhan and Planton (1989). Atmospheric stratification and surface exchange of heat and moisture, surface skin temperature (T_{skin}) of combined vegetation-ground layer calculation is described by Horváth et al. (2006). Richard's and heat flow equations are used calculating soil moisture and temperature, respectively.

Weather of the investigated day was determined by a slow moving cyclone with a center situated above the eastern part of the Carpathian Basin. Detailed description of the synoptic situation is presented in the paper of Horváth et al. (2005a).

Because storms formed both over flat and mountainous regions they serve good opportunity to investigate how the pattern of soil texture affects the cloud formation at different geographical conditions.

The region where the formation and development of the thunderstorms was investigated is a relatively flat area along the Tisza River. According to MM5 dataset, the vegetation characteristics in the modeled region are taken as plant *cultivations* from April. Parameter values as vegetation cover (*veg*) is 0.6-0.7, minimal stomatal resistance is 40 sm^{-1}, albedo is 0.19, and roughness length is 0.075 m. Leaf area (LAI) is estimated from the value of *veg*.

In the studied region soil texture is clay loam. However, sandy loam patches are also involved. Soil hydro-physical properties as parameters of the SWRC (minek a röviditése) function θ_S, Ψ_S, n, and the saturated water conductivity (K_S), field capacity soil moisture content (θ_f) and wilting point water content (θ_w) were calculated using pedotransfer functions of Nemes (2003) and Fodor and Rajkai (2005). The simulation results were compared to observations. The results obtained can be summarized as follows:

- The MM5 is an appropriate tool for modeling severe convective storms. Simulated precipitation fields agree well with observations in meso-β scale. Unfortunately no observation database was available to make the comparison at meso-γ scale.
- Both the intensivity and the lifetime of the thunderstorms depends on soil hydro-physical properties. Application of Hungarian soil characteristics resulted in formation of deeper thunderstorms with shorter lifetime. This difference in the dynamics could result differences in the accumulated precipitation. In the case of the experimental run the calculated accumulated precipitation was significantly larger than that in the case of reference run. This simulation result is not verified due to missing data at meso-γ scale.

However at the moment it is not proved that site specific soil parameters are more favorable than whatever else. This validation remains to be a task of future.

Conclusions

The collected case studies demonstrate soil's unavoidable effects on both climate and weather events. The role of soil is realized via soil's texture, color, humus and water content, and rather to the water resources.

Case studies showed examples how meterorological elements as precipitation, insolation and temperature are modified in a pine leave and a broad leave type forest. Literature and our studies as well verified the deterministic importance of the actual soil moisture content and status. This soil property determines the intensity of soil evaporation and plant transpiration, which is the most deterministic in relation to the atmospheric processes as climate and meteorology. Since soils in general are not without plant cover their climatic interactions always belong to the subject of bioclimate or biometerorology depending on the time and area.

The examples showed far do not cover all possible soil effects on climate or climatic effects on soil-vegetation systems. Since they do not contain such important soil processes as soil cultivation, infiltration, erodability, etc.

Most of our examples were focused on the importance and significance of the water flow in the soil and evaporation to the atmosphere directly from the soil surface or from the plant canopy. Gusev and Novak (2007) considered evapotranspiration as integrated value of soils or soil water resources. In general meaning Várallyay (2001) summarized climate change effects on soil processes.

Consequently exploration of soil's role in bioclimatology is an ongoing multidisciplinary task.

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