The Role of Soil in Bioclimatology – A Review

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Abstract: Soil's part in bioclimatology is not defined and formulated yet. We interpret soil together with its plant cover as primary climate modifier for organisms living on, and within it. At the same time evaporating soil together with its transpiring vegetation is affecting the climate, and functioning as secondary climate modifier in context of bioclimatology. Selected Hungarian studies are used to highlight four primary and three secondary soil modifier actions connected to bioclimatology. Both primary and secondary soil modifier roles coupled mainly to soil hydro-physical properties. The first primary soil climate modifier action is the dew formation in the surface of sandy soils. As dew 80 mm of water can annually be transported from the subsoil to soil surface. Positive water resource value of dew is still not completely accepted. The second primary soil climate modifier example presents different amounts of usable soil moisture resource in two oak forest habitats with different species composition of herbs. In the third primary soil example the microclimate of the wetter habitat with deeper soil and denser herb vegetation of the oak forest – estimated by inverse modelling – showed higher shading, air moisture content and lower soil coverage than that of dry one. In the fourth primary soil modifier example forest hydrology is quantified for a Scots pine forest. Amount of transpiration, evaporation, interception, and change in the soil water storage were quantified and modelled. As secondary soil climate modifier role CO_2 emitting of different plant production forms and land-uses is shown. Estimated CO_2 production burning fuels for soil and plant cultivation is one to threefold of the organic extensive and intensive plant production farm consecutively in 2001. For the estimative calculations cost data of the farms are used. Amount of CO_2 fixed in the crop biomass is also one to threefold as estimated with the regional scale formula of CEEMA (Canadian Economic and Emission Model for Agriculture). Two secondary soil modifier examples of soil texture and land use pattern's influence on local weather phenomena and near surface atmospheric processes as storm move and development are presented yet. Both studies demonstrate the significance of site-specific soil hydraulic parameters – as field capacity, usable and actual water storage – in formation of the local weather through the soil evaporation and plant transpiration in modelling studies. Of course variety of soil's role is much wider as the examples show and even it is not known completely at present. Soil's role in bioclimatology as new discipline will expectably be formulated in the future.

Keywords: soil hydraulic parameters; evaporation; transpiration; stand microclimate; storm formation

Subject of bioclimatology is for studying the effects of climatic conditions on living organisms (Encyclopedia Britannica). In this respect soil can considered to be operational modifier of climatic conditions for living organisms. Soil as boundary between the lithosphere and atmosphere forms habitat for plants being their water, and nutrient resource. Functionally vegetation is a part of soils. However, agriculture together with other human activities has transformed the land cover globally. Expansion of plough areas due to deforestation, application of mineral fertilizers, soil cultivation, and irrigation are responsible for the experienced climatic effects (Henderson-Sellers *et al.* 1993).

Enlargement of arable areas has – among others – changed the albedo of land's surfaces (Bonan 1997). For example, the albedo of chernozem soils has increased from 7 to 25% due to their lowered humus content, changed humus quality, and dryer soil conditions. The 10% increase of soil albedo would have to decrease air temperature with 1°C. However, increased greenhouse gas content of air retains the reflected radiation and compensates the temperature shift (Lettau *et al.* 1979). Drainage and water regulation of wetlands decreases the free water surfaces, and increases the surface albedo of areas.

However, above consequences of changes in soil use may act at different time and spatial scales depending on the type of exchange processes between the soil and atmosphere.

Várallyay (2002) summarized climate change effects on soils. Budagovsky (1985) stated that soil water is the main resource for terrestrial ecosystems, in spite that soil water reservoirs are filled up by precipitation, and capillary rise in case of close groundwater table. Evapotranspiration (ET) is the measure of soil water resource. ET is more accurate characteristic of soil water resource than soil water content. Soils control the transpiration rate of vegetation by the availability of stored water (Gusev & Novak 2007).

In order to supply the water demand of cultivated plants irrigation is applied in plant production. In spite of that irrigation may have local climate effects its significance is not negligible since about 17% of the agricultural area is irrigated worldwide. There was no detectable effect 10 m above of the irrigated fields, and 1 km far from the water reservoirs. But, increased precipitations were detectable in the neighbourhood areas in the months of irrigations (Moore & Ropstaczer 2001).

The ecological and hydrological state of the soil and vegetation can be described considering the fluxes of land–atmosphere interactions. Pielke *et al.* (1998) overviewed both the short-term (biophysical) and long-term (out to around 100 year timescales; biogeochemical and biogeographical) influences of the land surface on weather and climate. They establish that terrestrial ecosystem dynamics on these timescales significantly influence atmospheric processes. In studies of past and possible future climate change, terrestrial ecosystem dynamics are as important as changes in atmospheric dynamics and composition, ocean circulation, ice sheet extent, and orbit perturbations. Some simplified forms of the land-atmosphere interactions are built in the NCAR land surface model. That model includes soil and vegetation albedo determining the net radiation at the soil and plant surfaces (darker surfaces absorb more solar radiation); the effects of soil water and stomata physiology (e.g., dry soils have lower latent heating and higher sensible heating than wet soils); and heat storage of soil, in which the low heat capacity leads to large diurnal and seasonal temperature variations (Bonan 1997). Soil's thermal (heat capacity, thermal conductivity), and hydraulic properties (porosity, saturated hydraulic conductivity, saturated matrix potential, slope of water retention curve) vary continuously depending on the sand and clay content.

The land surface model is coupled to the atmospheric model to simulate atmospheric effects of land characteristics and land effects of the atmospherics (Bonan 1996a, b).

NCAR and its further developed NCAR MM5 version contain almost all important energy exchange and material transport processes determined or influenced by soil, which indicates soil's climate formation role. Of course land surface models involve parameters of vegetation as well.

As primary climate modifier soil's role thermally induced dew formation in dry sandy soil, evaporation (E) and plant ET depending on soil texture and related hydrophysical properties and measured moisture content of alluvial soils, different water resources of two oak forest habitats and the simulated microclimate in the different oak forest habitats, water balance elements of a Scots pine forest will be presented and interpreted. Climate modifier greenhouse gas fixations and emissions of different production forms, relationships between local weather and storm move and ET determined by the actual water-holding properties of soils are shown as secondary climate modifier soil's roles.

Primary soil's role in bioclimatology modifying climate parameters

Dew formation and plant water supply

Soil albedo depends on color, roughness and moisture content, and particle-size distribution (Carson 1982). As it is known light texture soils have low humus and moisture content and consequently high albedo. The sandy soils with high albedo reflect back around one third of the solar radiation. But in spite of the high reflection their surface can warm up above 60°C in summer period because of the extremely low heat conductivity of sandy soil due to its low water content. Daytime high temperature however drops close to 0°C in the evenings and nights. Repeated fluctuations of temperature generate vast water transport to soil surface from the deeper layers via vapour flow called dew formation. Dew formation on soils carries some bio- meteorological effects in dry sand areas studied by Szász (1967). According to his estimations 80–90 mm of water annually is transported to the surface from the deeper layers in sandy soils as dew. However, a meteorologist and an irrigation specialist questioned affectivity of dew in plant water supply (Bacsó 1967; Ravasz 1967). Ecologists assumes dew water role in only maintaining the root function of sand grass species in dry periods (Horton & Hart 1998).

Retaining water in and evaporating from the soil

Soils retain high amount of water in their pore space (Várallyay 2002). According to his estimation about 55 km^3 water can be stored in the soils of Hungary. This means that approximately one half of the annual precipitation can be stored in soils. This huge amount of water is partly evaporated directly from the soil or transpired from the plant's leaves. Meteorologists estimate the effective evaporation (E) of soils by the modified Turc formula (Varga-Haszonits 1969):

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

where:

k – empirical constant (0.75 for sand, 0.85 for loam, and 0.65 for clay)

W_0 – initial soil water amount in unit volume of soil (mm)

P – precipitation (mm) in the studied time period

E_0 – vapor pressure deficit of air (mm)

Bare soil evaporation depends on both meteorological variables as air temperature, air moisture content, wind speed, etc., and soil parameters as actual water content, and water conductivity. In the SOIL-model both liquid and thermally induced vapour flow is considered since the water and heat transport equations are coupled (Jansson 1996). The model was parameterised using measured soil properties and weather data of Gabčikovo (Rajkai *et al.* 2006) for soils in Ásványráró Hungary, and Čiližská Radvan Slovakia (Štekauerová & Nagy 2003; Nagy 2004). Calculated E by the modified Turc formula is higher than ET estimated by the SOIL model (Figure 1b). ET is determined by the available amount of soil water, while E by the water storage of the entire soil profile.

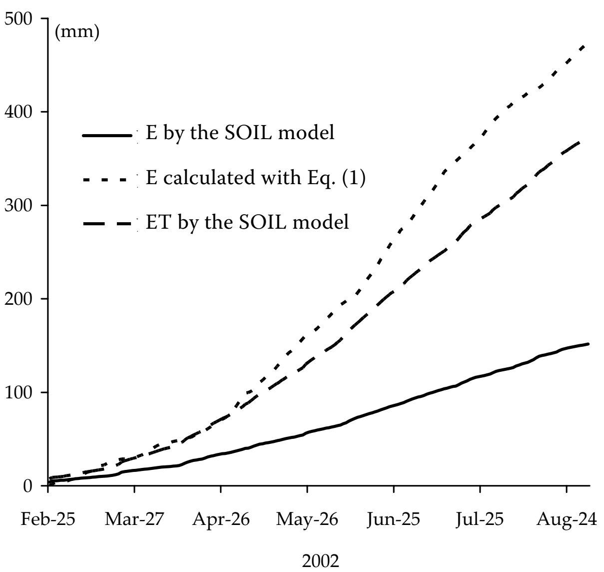

Figure 1a. Evaporation (E) of bare clay loam soil, evapotranspiration (ET) of rape crop, and evaporation (E) of the rape sown soil (in mm) (Rajkai *et al.* 2007)

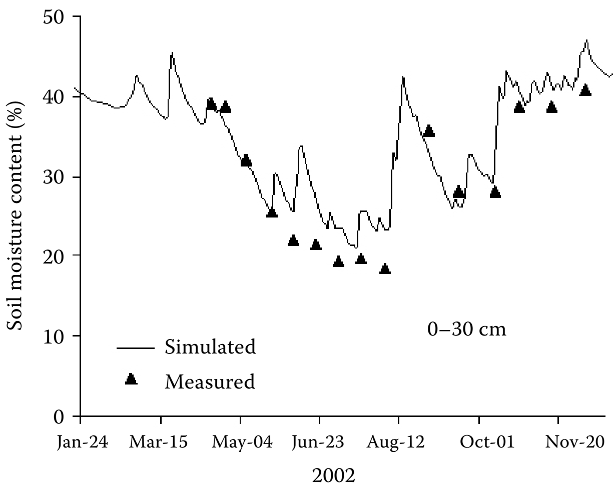

Figure 1b. Soil moisture contents (%) measured with neutron probe, and simulated by the SOIL model of 0–30 cm layer of the alluvial soil in Ásványráró (Rajkai *et al.* 2007)

E estimated by the SOIL model is the soil contribution in ET. E under plant canopy is smaller than that of bare soil. The simulated E and ET values in Figure 1b are from fitting simulated soil moisture contents to measured data (Figure 1b). However, simulated E and ET values have to be validated against site measurements.

Soil role in formation the hydrology of a lowland Scots pine forest

Contribution of litter cover, water retention characteristics (SWRC) and hydraulic conductivity (K_s) of soil on the annual water regime of a Scots pine forest were analyzed in lowland sand area by Gácsi (2000).

SWRC of the soil horizons and the litter cover are shown in Figure 2. Water conductivity curves of soil horizons estimated from the SWRCs and K_s values using the van Genuchten-Mualem conception (van Genuchten 1980) are shown in Figure 3.

Litter carpet in the forest retains water from precipitation and decreases soil evaporation. The water holding capacity of litter in the Scots pine forest is relatively considerable (Figure 2).

Moisture contents of soil layers were measured with CS615 type moisture meters (CS615 1999) buried in different depths of the soil (Gácsi 2000). Elements of the soil water balance were calculated from the soil moisture content data (Figure 4). From simulations of the SOIL model (Jansson 1996) the identical water balance elements with

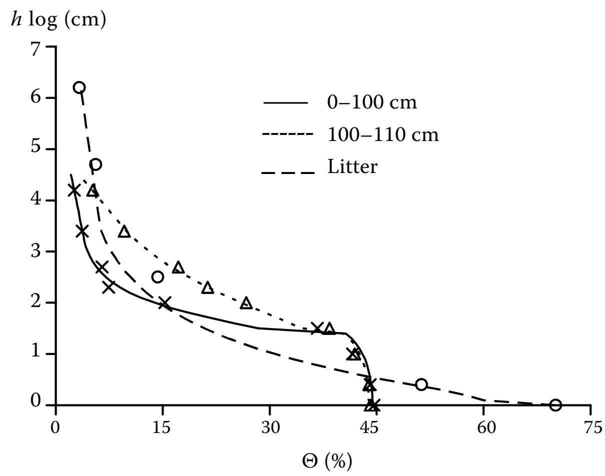

Figure 2. Water retention data and fitted van Genuchten functions of soil layers and the litter cover (Gácsi 2000)

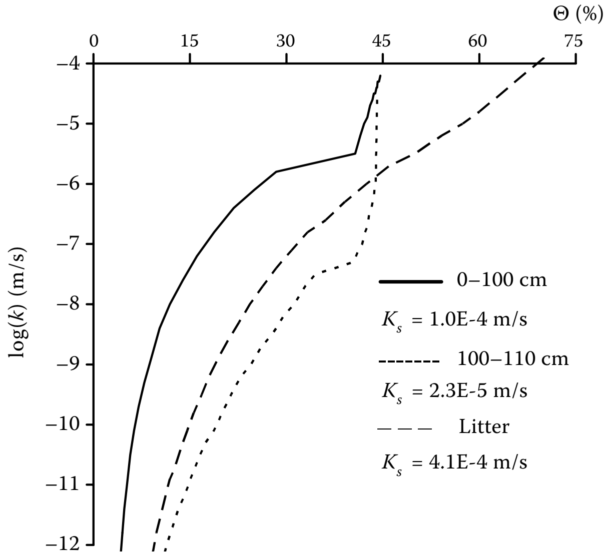

Figure 3. Estimated conductivity curves and measured saturated conductivity data (K_s) of soil layers and the litter cover (Gácsi 2000)

those are calculated were drawn out (see Table 1). ET varied between 310 and 340 mm, and 312 mm rainfall was measured above the tree canopy between 1th March, and 31th October.

About 80% of the precipitation fell through the tree canopy and reached the soil surface, and 95 mm was the interception. Almost each hydrological element of the Scots pine forest stand was quantified directly or indirectly. Both the litter cover and soil water storage contribution in the forest hydrology generate illustrative examples about soil role in the ecology of the lowland Scots pine forest.

Soil determined stand climate in a Sessile Oak forest

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 (Standovár 1988). 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 contains about 21% (g/g) stone in the 0–40 cm while in the 40 to 70 cm and in the 0–10 cm of the dry site about 35% (g/g) identically. The soil water storing capacity of the 0–70 cm soil layer at the moist site is 240 mm, and 110 mm of the 0–40 cm soil layer at the dry site.

Table 1. Simulated and calculated water balance values (mm) of the Scots pine forest in 1999 (Gácsi 2000)

Elements of soil water balance	Calculated	Simulated in	
		hourly base	daily base
In the vegetation period (1st March–30th September 1999)			
Soil water storage change (10–130 cm)	–65	–60	–65
Interception	95	92	75
Actual evapotranspiration	280–320	275	305
Deep drainage	150	174	169
Out of vegetation period			
Actual evapotranspiration	30	38	35
In the whole 1999 year			
Potential evapotranspiration	700	–	–
Actual evapotranspiration	310–350	313	340
Evaporation	100	106	106
Transpiration	210–250	207	234

Consequently the usable water amount for the vegetation is more limited at the dry site. Saturated conductivities and hydro-physical soil parameter values are given in Table 2. Inverse modelling was used to estimate the not measured stand's climate characteristics for the two forest sites (Rajkai & Standovár 2006). Modelling results are shown in Table 3.

Shading means the ratio of solar radiation reaching soil in the forest. According to model simulations 40% and 60% of the solar radiation penetrates through tree canopies at the moist and dry sites in the vegetation period. Shading increases during the development of foliage and parallel of that solar radiation decreases to 20% and 40% at the moist and dry sites till mid May. In the summer period the light intensity decreases down to 10% at the densely vegetated moist site. Air humidity is significantly higher under dense foliage. It reduces evaporation from the soil surface and transpiration of the herb layer. Soil coverage integrates all environmental factors affecting the water infiltration to soil. High soil coverage value e.g. 0.6 expresses vegetation coverage diverting the water falling through the tree foliage, plus the slope position of the soil at the site.

Simulated ET 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. Inverse modelling is based on model fit to the measured soil water content data shown in Figure 6. The sessile oak forest study clearly

Table 2. Soil parameters of the moist and dry site of the Sessile Oak stand (Rajkai & Standovár 2006)

Soil layer (cm)	Water conductvity (m/s)		Parameters of the van Genuchten water retention function			
	K_{sm}	K_s	θ_s (%)	θ_r (%)	α (cm^{-1})	n
Moist site						
0–40	6.3E-6	1.4E-6	75.9	0.0	3.395	1.19
40–70	3.4E-5	5.0E-6	48.5	0.22	0.007	1.52
Dry site						
0–10	7.0E-5	9.5E-6	53.3	0.12	0.0004	1.31
10–40	4.3E-5	1.1E-5	48.5	0.22	0.007	1.52

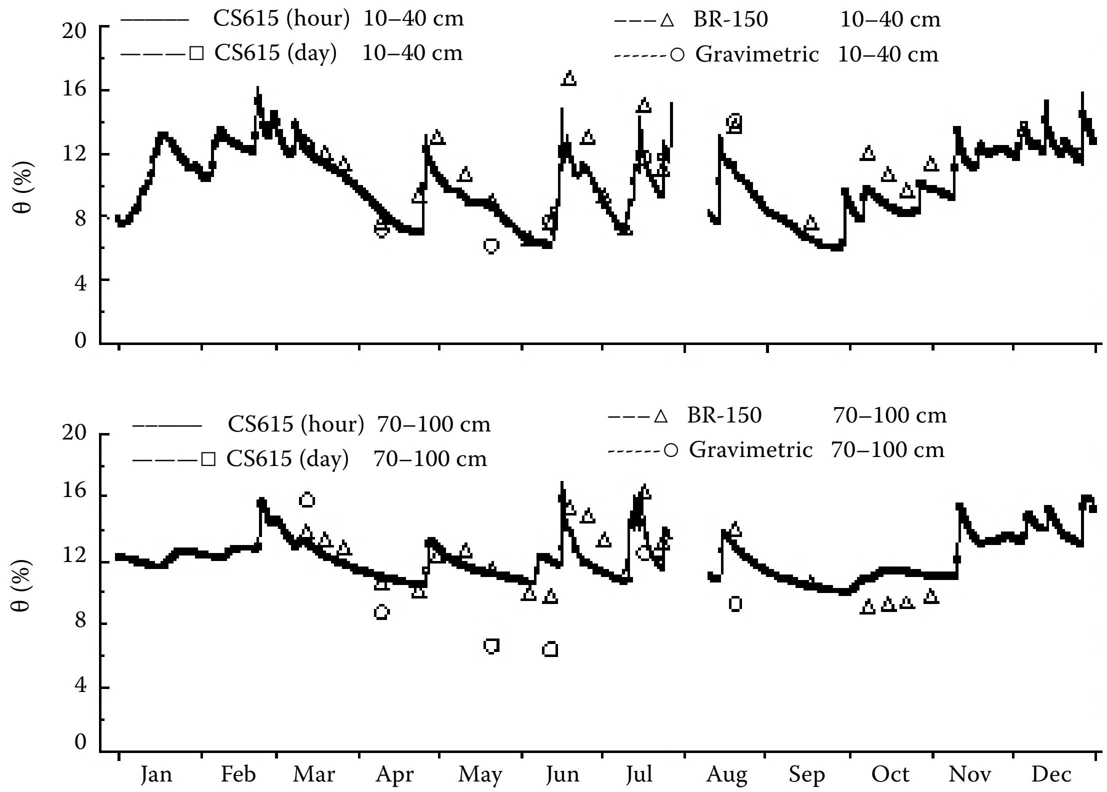

Figure 4. Campbell, capacitive probe (Δ) and oven dried (○) soil moisture content data (in %) in two depths of the Scots pine forest in 1999 (Gácsi 2000)

demonstrates soil effects on the herb vegetation, the stand climate and the soil water status at the differently vegetated forest sites.

This study together with previous ones gives examples for primary soil's climatic modifying effects. However, soil with its vegetation can affect the climate itself and through the modified climate it plays bioclimatic role.

However, the following examples illustrate secondary climate modifier character of soils.

Table 3. Moist and dry forest site characteristics estimated by inverse modelling (shading and soil coverage are fraction values, humidity is %) (Rajkai & Standovár 2006)

Meteorological and soil parameters	Moist site with deeper soil	Dry site with shallow soil
	1st November–1st April	1st November–1st April
Shading	0.6	0.4
Humidity	60	50
Soil coverage	0.1	0.3
	1st April–10th May	1st April–20th May
Shading	0.8	0.6
Humidity	80	60
Soil coverage	0.2	0.6
	11th May–1st June	21st May–31st October
Shading	0.9	0.6
Humidity	85	60
Soil coverage	0.7	0.6

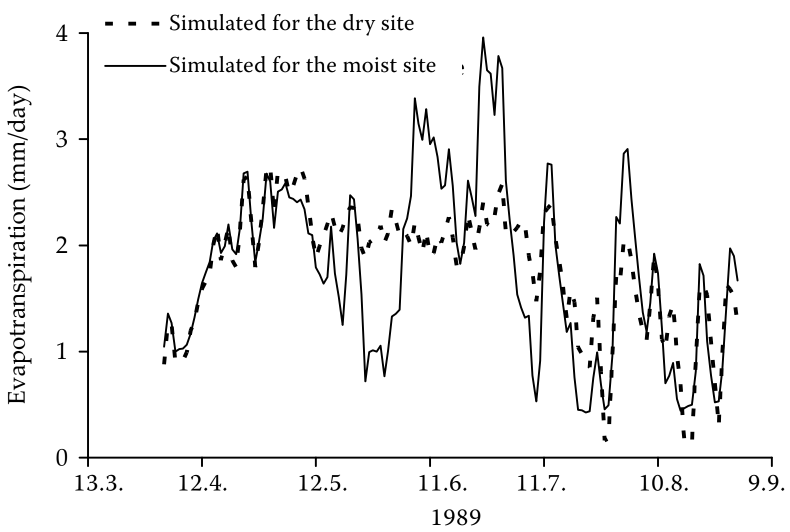

Figure 5. Simulated evapotranspiration time dynamics at the moist and dry forest sites (Rajkai & Standovár 2006)

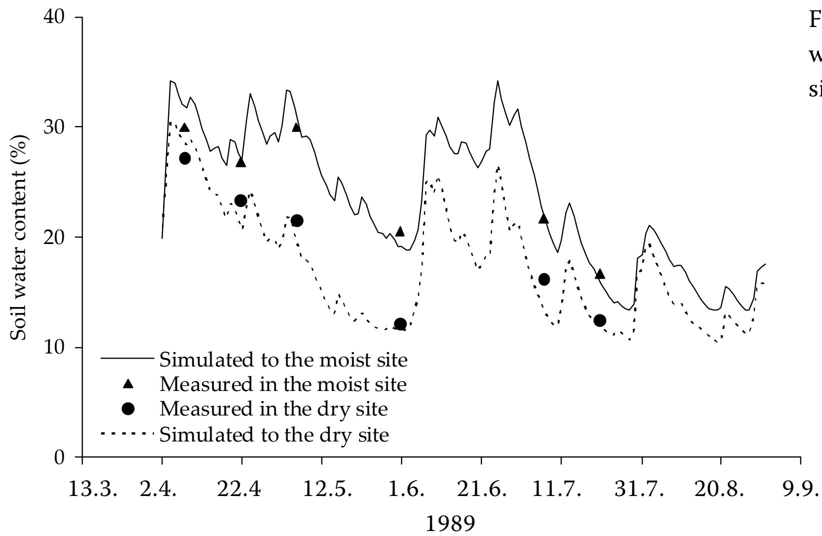

Figure 6. Measured and simulated soil water contents at the moist and dry forest sites (Rajkai & Standovár 2006)

Secondary soil's role in bioclimatology

Greenhouse gas (CO_2) emitting and fixing of different plant production forms

On global scale agriculture accounts for one-fifth of the annual increase of radiative forcing due to greenhouse gas emission. While agriculture related land-use change contributes about 14% to global emission of carbon dioxide (IPPC 1996). Carbon dioxide mitigation options include reducing agricultural emissions, sequestering carbon in soils and utilizing biomass for production of fuels. In order to estimate greenhouse gas fixations and emissions analyses were done using data from the Farm Accountancy Data Network (FADN) in Keszthelyi (2006) and Rajkai *et al.* (2007). Five years data of three farms were selected to represent different – intensive, extensive and organic – agricultural plant production and land use forms. Land size of the selected farms is varying around 60 ha in the same geographical, climatic and soil environment. Yields of the crops, sawn and harvested land areas of farms are shown for one year in Table 4.

CO_2 emission from crop's dry matter accumulated during the photosynthetic metabolism is estimated using the formula for the crop yields and plant residue of a crop (CEEMA 1999):

$$EC^p = Y^p\,(1 - W^p)\;BMS^p \times C \times 3.6664 \qquad (2)$$

where:
EC^p – CO_2 emission of the p^{th} crop (t/ha)
Y^p – yield of the p^{th} crop (t/ha)

Table 4. Farm data used to estimate CO_2 intake and later emission of plant biomass in 2001 (Rajkai *et al.* 2007)

Crop	Organic farm		Intensive farm		Extensive farm	
	land area (ha)	yield (t/ha)	land area (ha)	yield (t/ha)	land area (ha)	yield (t/ha)
Wheat	50	3.5	31	5.5	14	6
Corn	5	4.7	24.6	7.3	20	1.7
Potato			3.5	7.1		
Barley	7	2.1			3	5.2
Alfalfa	16	11.1			3	10.7
Grass lay	12	3.8				

W^p – water content of the biomass (mass fraction)
BMS^p – biomass factor of the p^{th} crop (total dry biomass dry yield ratio)
C – carbon content of dry plant material (0.45 g C per g dry matter)
3.664 – conversion factor between C and CO_2.

For the coefficients in Eq. (2) values of CEEMA (1999) were used. For CO_2 emission of fossil fuels the amount of fuel used for soil cultivations, sawing, harvesting, fertilization, plant protection, and etc. are estimated from the cost of machinery (Sulyok 2006). Gasoline energy content and conversion factor for liquid fuels is taken from the literature (CEEMA 1999). Distinction between intensive and extensive plant production was taken by leaving out such intensive cultivation forms as ploughing, chopping of plant residues setting up the machinery cost of the extensive farm. CO_2 emission of farms was estimated for 2001.

Because of the lack of relevant information other CO_2 emissions of the land use such as loss of soil organic matter due to tilling, biomass burning, manure application, and chemicals are not taken into account. According to the calculations farms produced 13, 7, and 4 t CO_2 burning fuels in the intensive, extensive, and organic order in 2001. These farms fixed 30, 23 and 10 t CO_2 in the produced crop's biomass between 2001 and 2005. This study applies the CO_2 fixation and emission estimating method of CEEMA (1999) at farm level. Both greenhouse gas fixation and emission depends on the cultivation form of plants (Rajkai *et al.* 2007). Of course land use type has only indirect bioclimatic effect through the change rate of atmospheric gas composition.

Role of soil texture and related moisture status in weather formation

Using a Thorntwaite-based biogeochemical model soil's impact upon climate parameters as monthly air temperature and precipitation was studied for Hungary assuming equilibrium between climate, vegetation and soil (Ács *et al.* 2007a). In the analysis 50 years data of 125 meteorological stations from 1901 to 1950 were used (Kakas 1960). Soil characteristics of the meteorological stations were taken from the thematic soil maps of Hungary (Várallyay *et al.* 1979). The hydro-physical functions of soil texture categories are parameterised after Nemes (2003). The wilting point (1500 kPa) and the field capacity (250 kPa) retention values were calculated using the pedotransfer function of soil texture categories. The performance of the Thorntwaite based model of potential evapotranspiration (PET) (Thornthwaite 1948) developed further including thermal index by McKenney &

Table 5. Soil parameters used in the MM5 Land Surface Model (θ_s saturated soil moisture content (%), Ψ_s saturated soil water potential (m), K_s saturated water conductivity (m/s), b pore size distribution index, θ_f field capacity moisture content (%), θ_w wilting point moisture content (%)) (Horváth *et al.* 2007)

Soil texture	θ_s (%)	Ψ_s (m)	K_s (m/s)	b (–)	θ_f (%)	θ_w (%)
Sandy loam	42.5	0.610	1.14×10^{-5}	3.97	28.3	9.9
Clay loam	43.0	4.170	3.05×10^{-6}	4.05	30.6	8.3

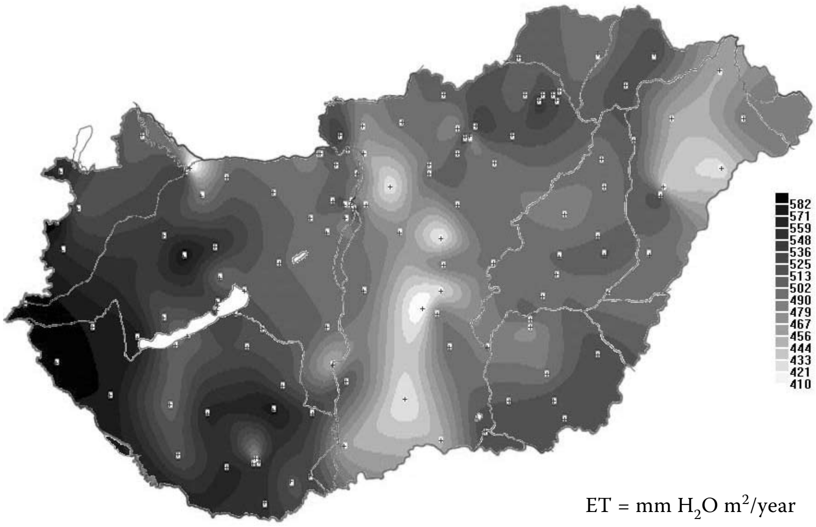

Figure 7. Map of Thornthwaite-based 50-year average evapotranspiration in Hungary (Ács *et al.* 2007)

Rosenberg (1993). The actual evapotranspiration (AET) was estimated from PET using the parameterization of Mintz and Walker's (1993). The model was tested with measured soil water content data of the Agrometeorological Observatory of the University of Debrecen (Szász *et al.* 2006).

Modelling showed that water holding capacity is the soil parameter affecting the flux of water vapour, and influencing the climate locally. The analysis indicated an unequivocal territorial distribution of annual ET. The map of estimated AET for Hungary is shown in Figure 7. The pattern of estimated AET shows a well-known distribution of plant productivity in Hungary illustrating soil's effect on the local climate. The annual AET ranges between 410 and 630 mm. AET is the largest in the western mountain regions of country, especially on the hills. Beside relief soil texture effect upon AET is definite. Texture effect is expressed especially in the sand regions, where the AET is around 420 mm/year. The pattern of estimated AET and water storing capacity of 1 m deep soils of the country is similar. AET in the western and southwest part of Hungary is larger due to higher precipitation and temperature of these regions. As local climate affects organisms in different parts of the country, consequently soils play a definite bioclimatic role.

Soil's impact upon storm formation

In meteorology the land-surface effects on cloud formation are well known. Pielke (2001) discussed the sensitivity of cumulus convective rainfall to the land-surface energy and moisture budget. Ács *et al.* (2005) reported that these land-surface properties are determined by the hydraulic properties of joint soil-vegetation systems and the land use. On this experience Ács *et al.* (2007b) attempted to correlate the convective storm event in 18th April, 2005 North-East part of Hungary with the land surface hydraulic properties using the NCAR MM5 model (Dudhia 1993). They compared simulated results to the accumulated surface precipitation data on satellite images.

The used land surface model coupled the Penman's atmospheric stratification modified potential evaporation (Mahrt & Ek 1984), the multi-layer soil model (Mahrt & Pan 1984) and the single-layer canopy model (Pan & Mahrt 1987). AET was simulated according to the moisture availability concept of Horváth (2005). For canopy resistance (Jarvis 1976) they used Noilhan and Planton (1989) relative stomata conductivity. The atmospheric stratification, the surface exchange of heat and moisture, the surface skin temperature of the combined vegetation-ground layers were done by Horváth *et al.* (2006). Richard's and heat flow equations were used for calculating the soil moisture and temperature, respectively.

The storm time development was investigated above a rather flat area along the Tisza River. Cereal plant cultivation was assumed to grow in the whole area from April. Soil texture in the region is clay loam with sandy loam patches. The van Genuchten parameters of the water retention functions and K_s values of the soils of the area were calculated using the pedotransfer functions of Nemes (2003), and Fodor and Rajkai (2005) (see in Table 5). Simulated 24 h accumulated precipitation fields in Figure 8b, and observed rain gauge network data collected on 19th of April, 2005 in Figure 8a show

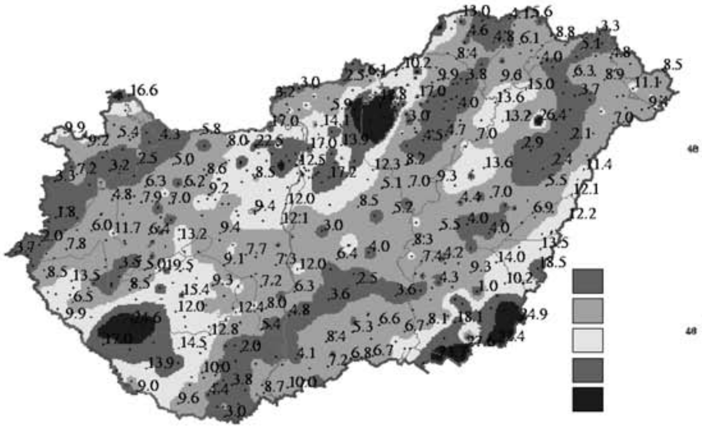

Figure 8. 24 hours accumulated precipitation observed at 06:00 a.m. 19th of April 2005 (a), and simulated accumulated precipitation fields (b); straight line shows the direction of storm move; P1, P2, P3 and P4 denote different precipitation forms (not used here) (Horváth *et al.* 2007)

definite similarity. Thunderstorms moved from northeast to southwest and left significant "tracks". Most of precipitation measured on the eastern part of Hungary fell between 12 and 18 h in 18th of April. The precipitation track starting from the northeastern part of Hungary can be well identified on the simulated fields (Figure 8b) as well.

The simulated accumulated precipitation fields showed profound impact of site-specific soil hydraulic properties upon storm processes demonstrating again the soil role in bioclimatology.

CONCLUSIONS

The collected case studies demonstrate a variety of primary (direct) and secondary (indirect) soil effects on microclimate and local weather events. Bioclimatic roles of soil were shown via soil texture, litter cover, actual moisture content, water storage, water retention and conductivity, and transpiration intensity of vegetation.

Case studies are divided into primary and secondary from the point of view of their bioclimatic effect. Primary cases showed how soil and its plant cover modify meteorological elements as precipitation, solar radiation and temperature in needle leave and broad leave forests. The shown examples verified deterministic importance of hydro physical properties and actual moisture content of the soil. Since these soil properties determine the intensity of soil evaporation and plant transpiration, which is significant in relation to the atmospheric processes. Since soils are rarely without plant cover their atmospheric interactions always in relation to biometeorology or bioclimatology.

Secondary soil effects mean soil texture related water storing capacity and plant cover influence on local weather and storm move and development. Examples were focused on the significance of water flow into soil and evaporation or transpiration of water to the atmosphere. Consequently exploration of soil's role in bioclimatology is expectably a developing multidisciplinary research field. Need of this new discipline may be accelerated by growing environmental and economical impacts of changing climate and weather extremes which are more and more obvious and pressuring.

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