MODELLING OF CLIMATE AND NET ECOSYSTEM EXCHANGE IN DEBRECEN

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Introduction
Debrecen’s climate has been studied by climate data processing (Justyák and Tar, 1994). However, Debrecen’s climate has not been studied by biogeochemically-based SVAT (Soil-Vegetation-Atmosphere Transfer) models. The purpose of this study is to investigate Debrecen’s climate using a Thornthwaite-based biogeochemical SVAT model. In doing so, Thornthwaite’s climatic formula is specified and the annual course of energy and carbon budget components is analyzed. The analysis refers to last few decades of the 20th century.

Methods
A Thornthwaite-based biogeochemical model consists of the Thornthwaite’s bucket model (Thornthwaite, 1948); the Peng’s soil respiration model (Peng et al., 1998; Breuer, 2004) and the Maisongrande’s net photosynthesis model (Maisongrande et al., 1995). Its input data are as follows: geographical latitude and longitude, monthly precipitation (P), temperature (T) and sunshine duration (SD), initial soil moisture content, soil hydro physical properties and monthly NDVI and albedo values. The output data are as follows: the Thornthwaite’s climate formula, soil water content in the root zone, actual (AET) and potential (PET) evapotranspiration, water surplus, water lack, soil respiration (SR), net primary productivity (NPP), net ecosystem exchange (NEE), radiation balance (Rn), latent heat flux (LE), sensible heat flux (H) and ground heat flux (G). Precipitation and temperature data refer to period 1951-2003; sunshine duration data to period 1971-2003, while NDVI data (Bartholy et al., 2004) to period (1982-2000).

Results and discussion
Climate and energy balance components
Debrecen’s climate is represented by Thornthwaite’s formula as $C_i$, $B_j$, $d$, $b_j'$. $C_i$: dry subhumid (moisture index is between -20 and 0), $B_j$: mesothermal, $d$: little or no water surplus and $b_j'$: ratio between summer and annual PET is 50-55%.

The annual course of energy balance components is presented in Fig. 1. $R_n$ changes between -90 ě 380 MJ m⁻² month⁻¹, LE between 0 ě 250 MJ m⁻² month⁻¹, while H between -80 ě 125 MJ m⁻² month⁻¹. LE is the greatest in June because of the precipitation maximum. Nevertheless, it almost vanishes in January (2 MJ m⁻² month⁻¹). H is as large in March (about 100 MJ m⁻² month⁻¹) as in June. Note that in October it is still positive (air is warmed by ground surface), but in November is already negative. G is negative in winter months and positive in summer months. Its annual sum is zero.

Carbon budget components
The annual course of C-budget components is presented in Fig. 2. NPP and SR have similar courses but their relation to each other is variable. This is reflected in NEE values. NPP is highest in July (56 gC m⁻² month⁻¹) and smallest in December (2 gC m⁻² month⁻¹). SR is maximum in June (60 gC m⁻² month⁻¹). In December it amounts to 16 gC m⁻² month⁻¹. Note that NEE is negative in the moist period from November to June, while it is positive in the dry period from July to October.
Fig 1: Annual course of radiation balance $R_n$, latent heat flux $LE$, sensible heat flux $H$ and ground heat flux $G$. Components refer to climate represented by Thornthwaite’s formula as $C_1 B_1 d b_2$ to the period 1971-2003.

Fig. 2: Annual course of net primary productivity $NPP$, soil respiration $SR$ and net ecosystem exchange $NEE$. Components refer to climate represented by Thornthwaite’s formula as $C_1 B_1 d b_2$ to the period 1982-2000.
Statistical relationships in the growing season

Growing season lasts from March to November. In this period, SR is well correlated (correlation coefficient $r$ is 0.83) with P. SR values are scattered between 320-450 gC m$^{-2}$ gs$^{-1}$, while P changes between 250-780 mm gs$^{-1}$ (see Fig. 3).

![Graph showing statistical relationship between soil respiration and precipitation in the growing season from March to November.](image)

Fig. 3: Statistical relationship between soil respiration and precipitation in the growing season from March to November.

Net carbon exchange between soil-vegetation system and air alters between 20 and $-100$ gC m$^{-2}$ gs$^{-1}$ (see Fig. 4). Correlation coefficient $r$ is $-0.65$, thus this relationship is not as strong as the SR/P relationship. $r$ is negative since SR is increasing faster than NPP by enhancement of P.

![Graph showing statistical relationship between net ecosystem exchange and precipitation in the growing season from March to November.](image)

Fig. 4: Statistical relationship between net ecosystem exchange and precipitation in the growing season from March to November.
Conclusions
In this study, Debrecen’s climate characteristics are investigated using a Thornthwaite-based biogeochemical SVAT model. It is used to estimate the annual course of energy-, water- and carbon budget components. Debrecen’s climate is represented by the Thornthwaite's formula as $C_1 B_1 d b_1$. NEE > 0 in the dry period between July and October and vice versa NEE < 0 in the moist period between November and June. $P$ is an important climatic element since it correlates by SR and NEE in an acceptable manner.

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References