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Temperature fluctuations in an undisturbed loess profile, Northeastern Bulgaria

Флуктуации на температурата в ненарушен льосов профил в Североизточна България

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Introduction

Due to the specific Aeolian-type deposition through the Quaternary period, the loess sediments together with paleosoils form a mighty, up to 100 m, loess complex in northern part of Bulgaria, most part of it being a phreatic zone (Minkov, 1968). In such conditions, the infiltration as a downward flux penetrates through the loess cover as a groundwater recharge (Huang et al., 2017). The main parameters defining the flux are respectively the precipitation and evapotranspiration rates. The latter, in case of bare soil, is strictly subject of specific air temperature and solar radiation variations, which are implemented in number of evaporation models (Alexandris et al., 2008). From the other hand, the loess complex is a basement for numerous important constructions of significant civil and industrial centres along the Danube River including Kozloduy NPP, potential Belene NPP, forthcoming National Repository for Radioactive Waste, chemical plants in Ruse town, some underground facilities, etc., e.g., Antonov (2003), Evstatiev and Evlogiev (2008). Thus, the solar and temperature data records are of a great importance for any water flow and mass transport model concerning civil engineering, agriculture and environmental aspects. In addition, as the water flux through loess occurs as a diffuse flow through the unsaturated zone, the changes of the temperature gradient in depth due to the air temperature variations/fluctuations could serve as an indirect indicator to the retardation properties of a loess unsaturated profile.

The present study describes the temporal variations of the soil temperature moisture in the upper part of unsaturated zone in respect to air temperature and solar radiation for the period of eighteen months.

Materials and methods

The experimental site with coordinates 43.819468°, 25.922163° is located in the vicinity of the town of Ruse at a high river bank.

There has been setup equipment with positioning of the temperature sensors. The temperature was measured by sensors (MPS-6 by Decagon company) installed at three depths, i.e. 0.55, 1.00, and 1.50 meters from the land surface. The accuracy of the sensors was ±1 °C with resolution of 0.1 °C. The air temperature was measured by OEM humidity and temperature transmitter with accuracy ±0.3°C at 20°C, with resolution of 0.1°C at 25°C and recording range of –40°C to +60°C.

In addition, the solar radiation was measured by a solar radiation sensor, in fact measuring the solar radiation flux from a field of view of 180 degrees with of 5% and spectral range of 380–1120 nm. All the equipment was operated by the GPRS datalogger produced by ADCON Company. The data was collected at every 20 minutes interval for the period September 2015–February 2017. The exact specifications of the used equipment and the procedure for installing the underground sensors are described in details in Antonov et al. (2015).

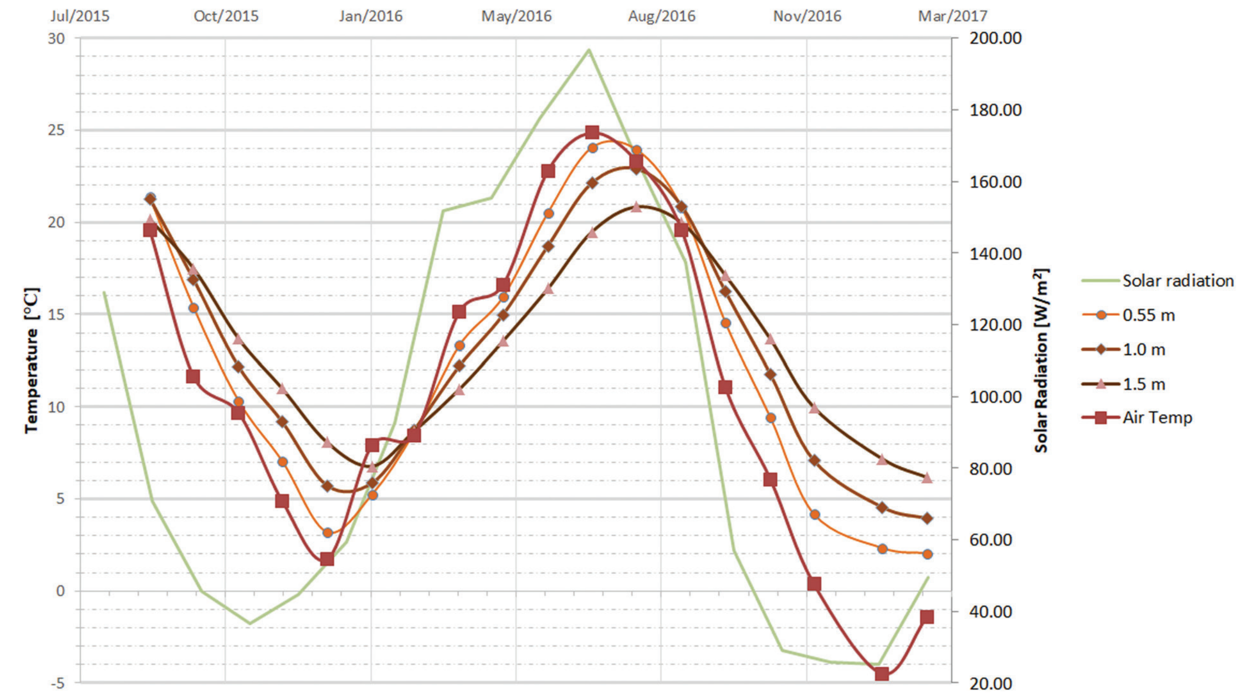

Fig. 1. Monthly variations of the solar radiation, air temperature and soil temperature in the upper part of the loess deposits

Results and discussion

Specific soil profile temperatures, air temperature and solar radiation as monthly average values are presented. In general, the air temperature is in strict relationship with the solar radiation values. On the other hand the soil temperatures also follow the pattern of solar radiation and air temperature with some specificity. From the period of September 2015 to February 2016, late summer – late winter, the temperatures in the loess profile are in reverse order regarding the air temperature, e.g. the deeper the sensor is the warmer the soil. This is due the properties of the loess massive to keep the temperature aiming its porous structure. From March 2016 to September 2016, spring – late summer, the temperatures are opposite − closer to the surface higher temperature. Finally, from September 2016 to February 2017, again the "late summer – late winter" pattern occurs (Fig. 1). In fact, the data show that the most upper part of the studies profile (0.55 m) is the most sensitive one, due to the air temperature changes. In addition, there is a kind of retardation of the temperature variations. Another observed fact is that the temperatures in the loess profile never have become negative although the air temperature is strictly below zero centigrade in the period November 2016–February 2017. This is an important fact in the future water flow modelling procedures.

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