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Determination of the amount of dew using weighing lysimeter data

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Zusammenfassung

Aktuelle Entwicklungen in der Lysimetrie ermöglichen die Erfassung von Wasserbilanzkomponenten mit hoher Genauigkeit und hoher zeitlicher Auflösung. Dadurch können Niederschlag und Tau, als ein Teil davon, direkt aus Lysimeterdaten ermittelt werden. Neben präzisen Messeinrichtungen wie Wiegezellen, ist dafür eine entsprechende Datengrundlage notwendig. Um eine solche zu schaffen wurde ein Verfahren zur Glättung von Lysimeterdaten auf Wiegedaten der Lysimeterstation in Karcag (Ungarn) angewendet. Das Verfahren benutzt natürliche kubische Splines, um Schwankungen durch Messrauschen zu minimieren. Die Glättungsparameter wurden so angepasst, dass auf Basis der bearbeiteten Datenreihe sowohl Verdunstung als auch Niederschlag – inklusive Tau – ermittelt werden konnten. Abschließend wurde die Taumenge auf einem Lysimeter mit Grasbewuchs für eine 18 monatige Periode quantifiziert.

Schlagwörter: Datenbearbeitung, Glättungsfunktion, Wasserbilanz, Niederschlag, Verdunstung

Summary

Recent advances in lysimetry facilitate measuring water balance components with high accuracy and high temporal resolution. As a consequence, precipitation as well as dewfall as a part of it can be determined directly from lysimeter data. Beside precise measurement equipment such as load cells, adequate data management is required to provide an appropriate database for such a purpose. In order to improve data with respect to the determination of dew, a smoothing method that uses natural cubic splines was adapted to the weighing data of the lysimeter station in Karcag (Hungary). Smoothing parameters were modified in a way that the resulting dataset represented both evapotranspiration and precipitation including dewfall. Finally, the latter was quantified on a lysimeter grown with grass for an 18-month period.

Keywords: data processing, smoothing function, water balance, precipitation, evapotranspiration

Introduction

Dew denotes humidity condensing on plants, soil, or other surfaces near the ground. As a fraction of precipitation, dew is a component of the hydrological cycle ("non-rainfall water"). Its relevance for the water (and energy) balance of a particular area depends on the environmental conditions. In arid or semi-arid climates the amount of dew can exceed that of rainfall, or even be the sole source of liquid water for plants (Agam and Berliner 2006). On the other hand, in most climates of the world the annual average is too small to compete with rain. Against this background, it might be interesting to evaluate the relevance of dew for the water balance, for example, in areas prone to drought stress at least periodically (e.g., Nolz et al. 2014).

The actual amount of dew depends on meteorological conditions and surface properties. Hence, a representative quantification requires that plants, leaves, or whole soil columns are placed on a balance with their surface at the same height and in the same surroundings as would occur naturally (Agam and Berliner 2006). Gains and losses of mass can then be attributed to certain water balance components such as dew. Fortunately, recent advances in lysimetry allow measuring water balance components – including precipitation and dew as a fraction of it – with high accuracy and high temporal resolution (e.g., Meissner at al. 2007, Nolz et al. 2014). Beside precise measurement equipment such as load cells, adequate data processing is required to provide an appropriate database for such a purpose. As data are generally noisy, data processing by means of smoothing functions can help obtaining continuous and accurate data series of lysimeter mass changes (Nolz et al. 2013).

The aim of this study was to improve data processing and determine the amount of dew based on weighing lysimeter data of Karcag Research Institute (KRI), Hungary.

Material and Methods

In total, six weighing lysimeters exist at KRI (the only ones in Hungary) with surface area of 1.7 m² and depth of 1 m. This study focuses on the water balance of a grass covered weighing lysimeter (*Figure 1*) during the study period from 1st April 2015 to 30th September 2016. Measurement frequency was 10 minutes; accuracy of the weighing system was 0.1 kg (equivalent water height: 0.06 mm). Seepage water was frequently collected at a bottom outlet and quantified. Rainfall was measured by a rain gauge at the meteorological station. The lysimeter was irrigated from time to time. All data were registered in a standard spreadsheet.

The basis for quantifying precipitation (*P*) and evapotranspiration (*ET*) was a simple water balance equation with the measured quantities on the left-hand side and the (yet

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Figure 1: **The grass covered lysimeter at KRI.**

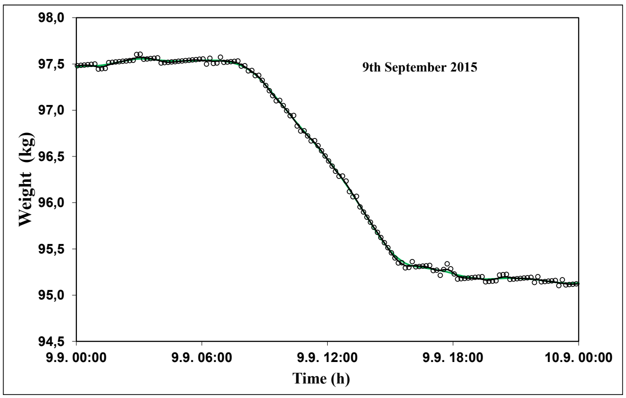

Figure 2: **Smoothed daily weight changes in the grass covered lysimeter [*y-axis:* "Nominal weight (kg)"; *labelling font might be larger; caption:* nominal lysimeter weight (including changes due to water outflow at the bottom): dots represent 10-minutes data, line represents smoothed data].**

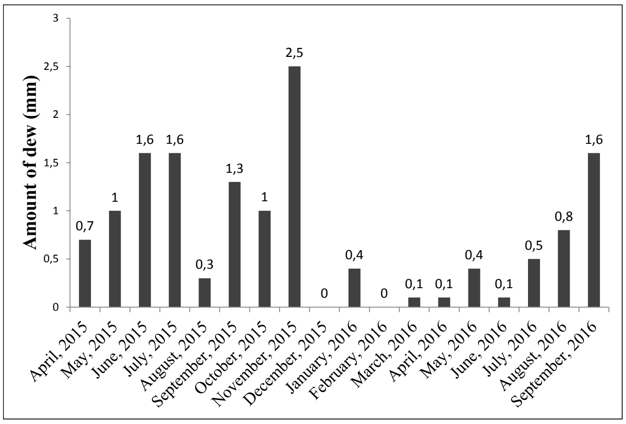

Figure 3: **Monthly dew amounts measured on the grass covered lysimeter.**

unknown) boundary fluxes between soil and atmosphere on the right-hand side (Eq. 1).

$$\Delta W + SW = P + I - ET \quad (1)$$

(ΔW = change of profile water content, SW = seepage water at lysimeter outlet, P = precipitation on the lysimeter, I = irrigation on the lysimeter, ET = evapotranspiration from the lysimeter; all dimensions are lengths)

The fundamental dataset contained the 10-min-data of lysimeter weight (changes equaling changes of water content) and seepage water collected at the bottom outlet of the lysimeters, from which a nominal time series ($W + SW$) was calculated. To be able to detect also minor changes due to dew formation, this time series was processed using a smoothing method based on natural cubic approximation splines as introduced by Nolz et al. (2013). Afterwards, changes between time steps of the smoothed dataset $\Delta(W + SW)$ were considered as precipitation if positive or evapotranspiration if negative. (Irrigation amounts could be separated directly, since they were known from record keeping.) Dewfall was considered when precipitation was detected and at the same time no rainfall occurred.

Results and Discussion

We studied the nominal time series of lysimeter weight (including seepage water) over the study period on a daily basis and indicated periods when positive weight changes due to dew were evident (visible). *Figure 2* exemplifies such a typical daily course for the grass covered lysimeter. It is obvious that the jumps between adjacent data points reveal data noise rather than changes due to precipitation or evapotranspiration. Data smoothing minimised these jumps and allowed interpreting the sequence in a more realistic way. On this basis, the course of the smoothed data points reproduce a slight increase due to dew (during night) and a substantial decrease due to ET (during day).

By means of this dewfall identification method based on the application of the smoothing function, we determined the daily amounts of dew fallen on the grass covered lysimeter in the whole investigation period and calculated the monthly values (*Figure 3*).

On this basis we determined the daily amounts of dew fallen on the grass covered lysimeter in the whole study period and calculated the monthly values (*Figure 3*). Accordingly, 14 mm of dew occurred during the 18 months of the study period. As no other reference data about the amount of dew was at our disposal, we could not compare them for evaluation. Nevertheless, we consider these values quite low. In order to evaluate the results, it will be necessary to estimate the amount and occurrence of dew using an ET-model based on an independent dataset of meteorological data – for instance, after Penman and Monteith (Allen et al. 2005, Nolz et al. 2014). Furthermore, the parameterization of the smoothing function should be reconsidered in order to minimize noise on the one hand, but not lose information (by over-smoothing) on the other hand.

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