Relationship of Transpiration to Rainfall, Air Temperature and Soil Moisture in a Mountainous Region

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Abstract

Direct measurement of transpiration in mountainous regions is of interest to hydrologists, as it is the part of evapotranspiration directly used by vegetation. Transpiration is thus considered to be the main biological component within the hydrological cycle. The paper presents data on measurements of the sap flow through selected representative trees, as related to the air temperature, rainfall, and soil moisture in surrounding areas. The data were collected during vegetation season 1995 at an altitude of 1,100masl in the experimental mountainous catchment of Jalovecky Creek in the western Tatra Mountains. The results shown in Figures 1 to 4 clearly indicate very complex relationships between transpiration and related hydrometeorological characteristics. They also suggest a close relationship between the diurnal course of transpiration and the easily measurable air temperature, as well as between the daily transpired volumes of water to disposable soil water resources.

Introduction

Transpiration is the main biological component in the hydrological cycle. The survival of vegetation in the Hindu Kush - Himalayan region depends on the availability of water for transpiration. However, the role of transpiration depends in turn on the type of vegetation cover, and so it is highly related to all human activities in the very fragile mountainous ecosystems. Naturally, this same component will be among the first influenced by climate changes.

The water balance of a catchment is basic to any hydrological study, but it is only usable if all the acting components are determined. Besides precipitation and runoff, the analysed complex system encompasses the areal evapotranspiration and soil water storage in the catchment. The evapotranspiration represents the evaporation from various surfaces and transpiration by vegetation. In most cases, the actual evapotranspiration is calculated from meteorological data only and therefore the actual transpiration, which plays so decisive a role in the environment, is just estimated or not taken into account at all.

Methods Used

Direct measurement of transpiration was carried out by the heat balance method of Cermak et al. (1973) and Kucera et al. (1977). The method is based on heating up the sap flow within a tree trunk and measuring the cooling effect related to the speed of sap in hydroactive xylem. Continuous measurements allow one to determine the intensity of transpiration in 20 minute intervals and daily

transpired totals. The pine tree was selected as the representative species for the experimental plot (1,100masl) in the Jalovecky Creek catchment where the hydrological balance has been computed by Kostka and Holko (1996). The mean evaporation with respect to elevation has been estimated by Miklanek (1994). The actual relationships of different hydrometeorological characteristics to transpiration was analysed by Molnar and Meszaros (1990, 1994, and 1994a). Data presented on Figures 1 to 4 were collected during the vegetation season in 1995. The final analysis and water balance computations are not included in this paper.

Discussion

Figure 1 shows the rather close relation of daily courses of transpiration to the air temperature measured two metres above the ground. An even stronger relationship exists between transpiration and air temperature over the canopy. However, such data are usually not available for remote mountain areas. The relationship documented in Figure 1 allows the air temperature along with other characteristics to be used to compute transpiration.

Figure 2 shows how rainfall reduces or eliminates actual transpiration. On the other hand, it recharges the soil water resources (see Fig. 3) and so contributes to the process of transpiration during the next period.

The last Figure 4, indicates the very delicate relationship between soil moisture and transpiration. The low soil moisture content within the root zone limits the transpiration, thus allowing the accumulation of soil water for later use. Measurements of the soil moisture were made to depths of 30cm only, which is reflected in the rather wide dispersion of values over the moving average.

Conclusions

- Determination of areal evapotranspiration presumes knowledge of the transpiration component that is valid for various vegetation species within the basin.
- Knowing the actual evapotranspiration allows the water balance, including corrections for precipitation, to be computed.
- Directly measured transpiration as an element of actual evapotranspiration is the biological component of it and hence affected by anthropogenic influences and possible climate changes.

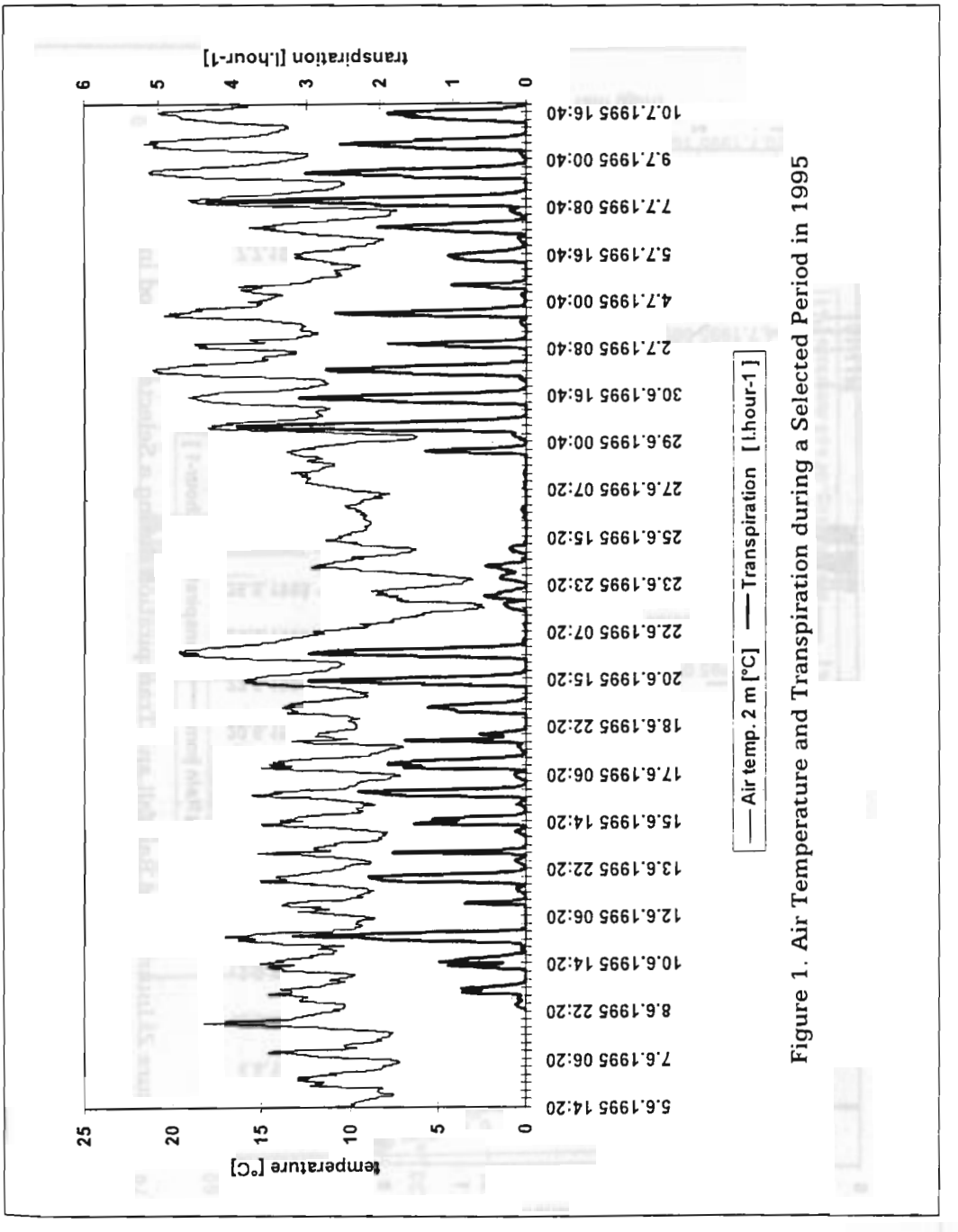

Figure 1. Air Temperature and Transpiration during a Selected Period in 1995

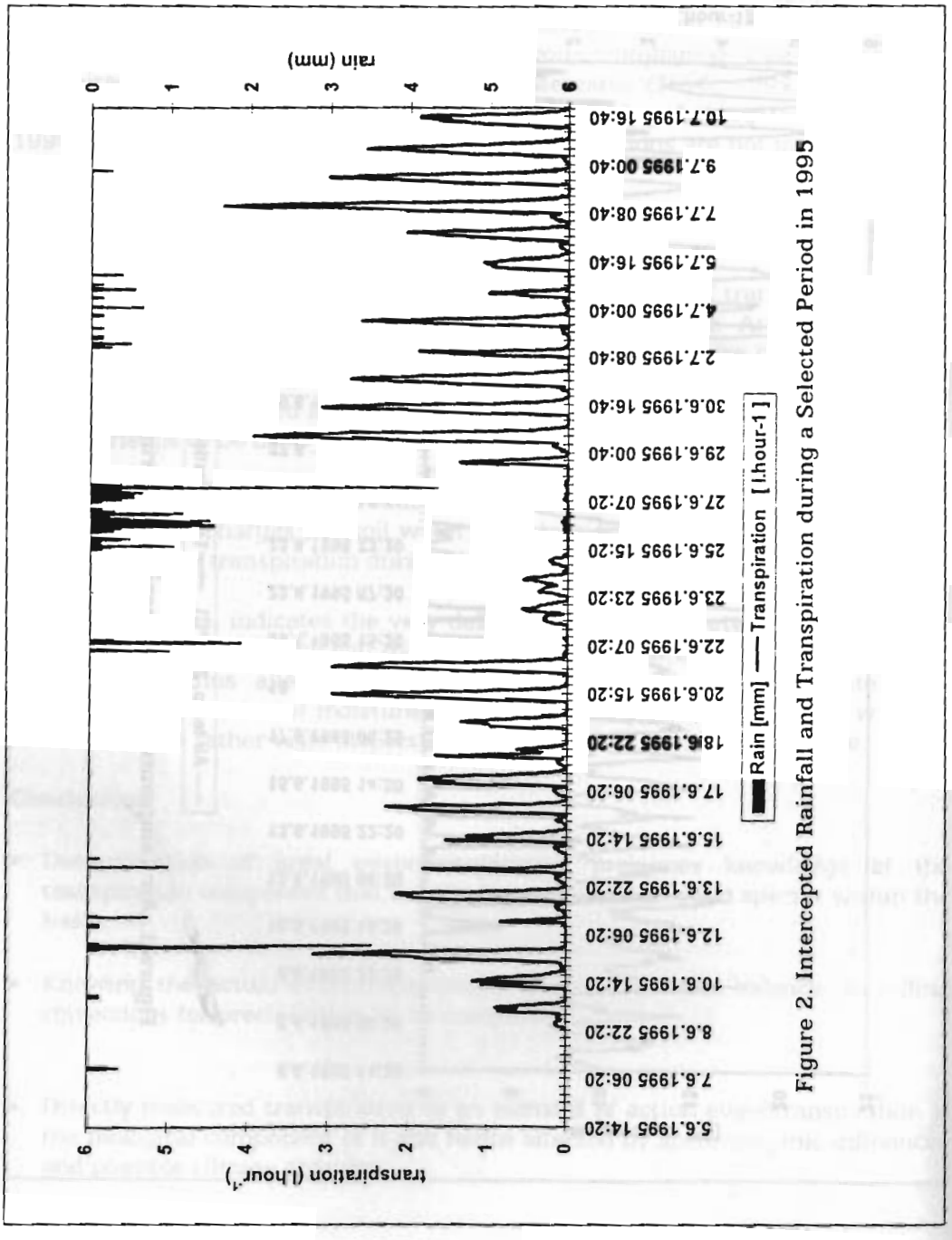

Figure 2. Intercepted Rainfall and Transpiration during a Selected Period in 1995

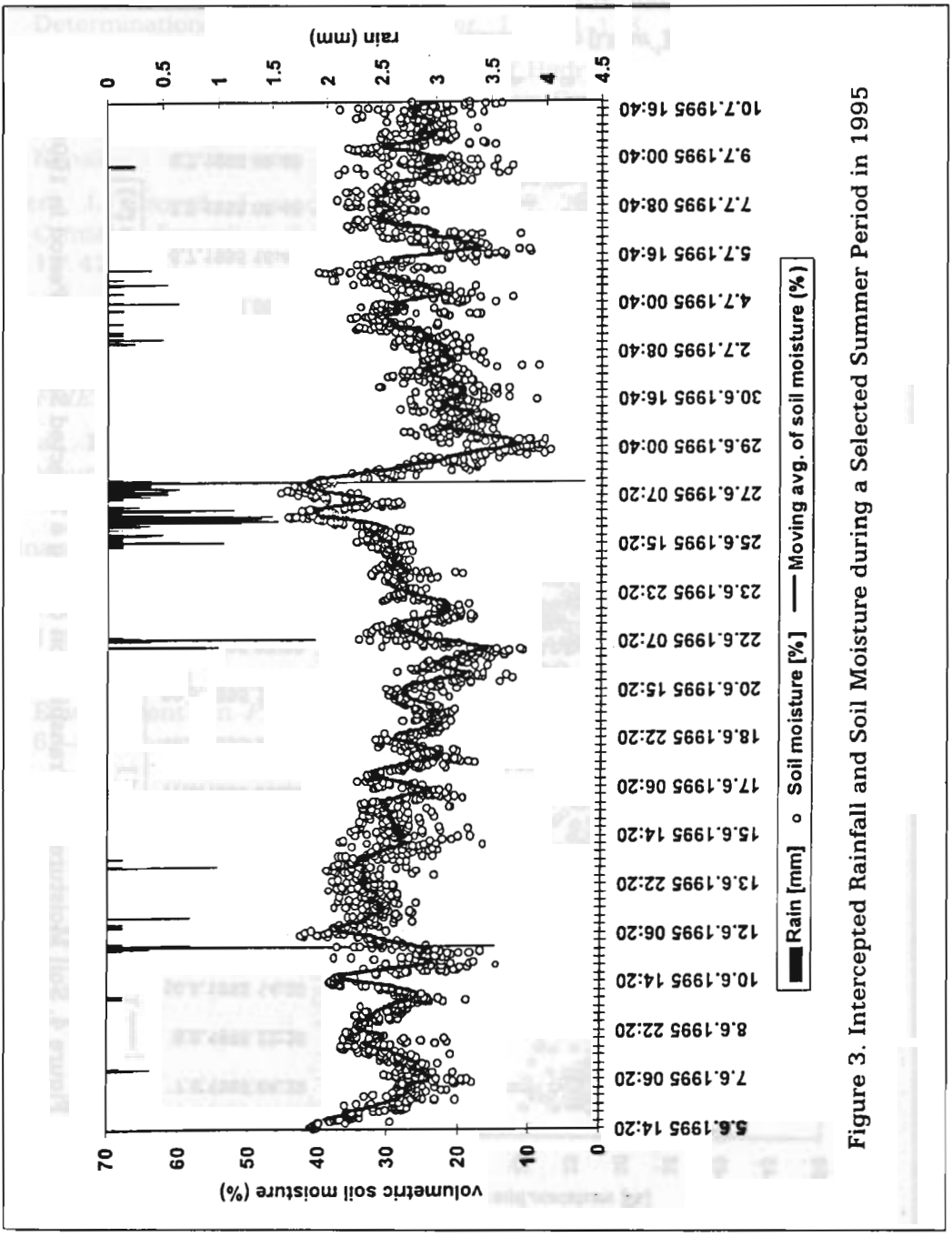

Figure 3. Intercepted Rainfall and Soil Moisture during a Selected Summer Period in 1995

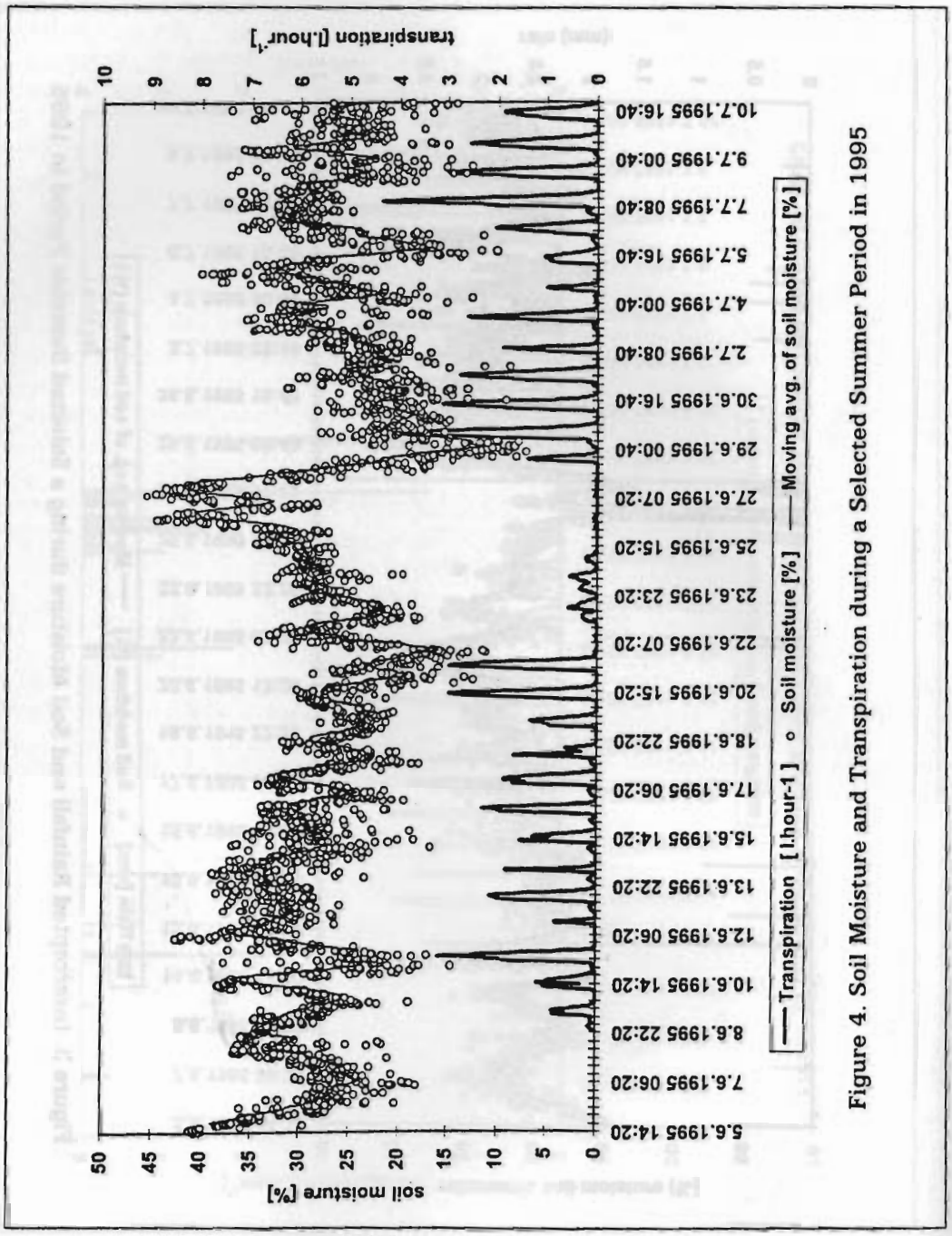

Figure 4. Soil Moisture and Transpiration during a Selected Summer Period in 1995

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