Changes in Components of the Water Balance in the Croatian Lowlands

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With 4 Figures

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Summary

This paper deals with variations and trends in some components of the water balance: the soil water content; evaporation loss from the soil (from the surface and underlying layers); transpiration; ground water recharge and runoff. These components are calculated by means of the Palmer procedure. This analysis is based on data from Osijek, Croatia from this century (1900–1995). Besides the meteorological input parameters necessary for the water balance calculations, i.e. precipitation, temperature and relative humidity, the pedological characteristics of this area have also been taken into account. Fluctuations have been considered by means of the 11-year binomial filtered series and linear trends were tested by means of the Mann-Kendall rank test. For a closer look on the trends of water balance components, a progressive analysis of the time series was performed, too. The results show a significant increase in potential evapotranspiration and evapotranspiration and decrease in runoff and soil water content has occurred during the century.

1. Introduction

Climate variability is important for the design and management of water resource systems, because the social benefits derived from these systems are direct functions of their reliability. Water resource systems have been designed and are being operated on the assumption that future climate variations might be expected to be similar to those observed within the past 30 to 50 years. At present, many climatologists agree that large parts of the Earth surface have warmed up over the last hundred years. The observed warming, as well as precipitation anomalies, is not uniform around the globe, so it is reasonable to consider recent climatic variability, in particular long-term series of meteorological variables in regions with different hydrologic conditions, in order to assess what impact variability has on stream-flow variations. This paper presents the results of fluctuation and trend analysis of several meteorological variables and the water balance components calculated for the long-term data series of the Osijek meteorological station, Croatia.

2. Data and Method

The mean annual and warm season (from April until September) data of meteorological parameters (temperature, precipitation and relative humidity) and the water balance components (potential evapotranspiration, evapotranspiration, loss, recharge, runoff and soil water content) have been analysed for the period 1900–1995, at Osijek (89 m a.s.l., 45°32'N, 18°44'E), situated in the Drava river basin, Croatia, in the southern-most part of the Pannonian lowlands in Central Europe.

Mean annual statistics of meteorological and water balance variables have been calculated for
the 1961–1990 reference period recommended by the WMO as the period representing the present climate (Jagannathan et al., 1967). In order to eliminate short-term fluctuations, an 11-year binomial average filter has been applied to the original data series. Tendency is discussed on the basis of the linear trends tested by means of the Mann-Kendall rank statistics (Mitchell et al., 1966). For the series of water balance components, which showed a significant trend, identified by the Mann-Kendall coefficient, a progressive analysis of the time series was performed in order to determine the exact start and end of the trends (Sneyers, 1990).

The water balance components have been obtained by means of the Palmer procedure (Palmer, 1965; Alley, 1984) based on the relation:

\[ P + L = ET + R + RO \]

where \( P \) is precipitation, \( L \) water loss from soil layers, \( ET \) evapotranspiration, \( R \) ground water recharge and \( RO \) runoff (all components are in mm). Besides the meteorological parameters, the pedological characteristics of the analysed area have also been taken into account. The presumption was that at the beginning of the calculation period (January 1900) the soil was saturated at its maximum capacity of 400 mm.

3. The Seasonal Cycle of Meteorological and Water Balance Parameters

The annual precipitation regime in this area is continental, with a minimum in winter (February, 40 mm) and a maximum in summer (June, 88 mm) (Fig. 1). The annual total is 651 mm. The warm season (April–September) is characterised by more precipitation (57%) than the cold season (October–March). From April to August, and also in November, each month receives a 8–13.5% part of annual precipitation (the maximum being in June), while in September and October and from December to March, these amounts are 6–7% per month. The highest monthly variability occurs in October (\( c_v = 81\% \)) and the lowest in June (\( c_v = 39\% \)). The average monthly temperature is highest in July (21.1 °C) and lowest in January (−1.2 °C). The mean monthly relative humidity values are between 72% in July and 90% in December, and they are more stable during the warm season.

Average annual evapotranspiration is 596 mm per year during the reference period (1961–1990) which represents 90% of the annual precipitation. 81% of the annual ET takes place during the warm season (Fig. 1) and reaches 129% of the precipitation amount in this period. This has an impact on water loss from the deeper soil layers, which in the warm season amounts to 90% of the annual total. On the other hand, most recharge (79%) and runoff (73%) occurs in the cold season. In an average year, the soil is almost saturated (more than 300 mm of water) from January to June, while even in the driest month (September) there is more than 200 mm of water in the soil. It is obvious, therefore, that the soil in this region has a high moisture content.