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Trends in reference evapotranspiration in the context of climate variability in Poland (1971-2010)

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Evapotranspiration is an integrated effect of evaporation from the soil and transpiration from plants. It is difficult to be measured so FAO (Food and Agriculture Organization) established guidelines for estimating evapotranspiration in different conditions using the Penman-Monteith (PM) method. The basic variable is reference evapotranspiration (RE) which denotes evapotranspiration from the uniform cover of grass of 0.12 m height, well watered, 70 S/m surface resistance and albedo 23%. Reliable calculations of RE require lots of meteorological data which frequently are not available. The solution is the regional calibration of simplified equations against Penman-Monteith method with a complete data set.

The main objectives of this study were (1) to calibrate the Hargreaves and simplified Penman-Monteith equations for conditions in Poland and (2) to assess the possible changes in reference evapotranspiration in the context of recent climate variability.

Simple and multiple regression procedures together with the GRG (Generalized Reduced Gradient) approach and a 40-year long set of daily data of seven meteorological variables were used to optimize Hargreaves and PM evapotranspiration models for conditions in Poland. Standard Normal Homogeneity and Bivariate tests were applied for detecting possible inhomogeneities, whereas the Mann-Kendall test was used to examine trends in meteorological variables at 31 stations in Poland.

New calibrated equations were developed in this study: the Hargreaves model for Poland and the simplified PM model for Poland. Increasing tendencies in the monthly series of reference evapotranspiration were detected in Poland. The most distinct trends occurred in southern Poland in April e.g. in Opole (PM method: +0.4 mm/year, $p<0.001$). These results coincided with increasing trends in the mean (Opole: +0.067°C/year, $p<0.001$) and the maximum (Opole: +0.098°C/year, $p<0.001$) air temperature, sunshine duration (Opole: +2.09 hour/year, $p<0.001$) as well as decreasing trend in relative humidity (Opole: -0.17%/year, $p<0.01$).

Taking into account that there is no statistically significant trend in precipitation in many areas in Poland (e.g. Opole, for April: -0.31 mm/year, $p>0.05$), increasing evapotranspiration may cause a water deficit in Poland. Especially, the southern and central parts of Poland can be potentially affected by spring droughts.