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Combined Deterministic and Stochastic Approach to Determine Spatial Distribution of Drought Frequency and Duration in the Great Hungarian Plain

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Abstract

Drought is one of the major weather driven natural hazards, which has most harm impacts on environment, agricultural and hydrological factors than the other hazards. In spite of the fact that Hungary – that country is situated in Central Europe – belongs to the continental climate zone (influenced by Atlantic and Mediterranean streams) and this weather conditions should be favourable for agricultural production, the drought is a serious risk factor in Hungary, especially on the so called "Great Hungarian Plain", which area has been hit by severe drought events. These drought events encouraged the Ministry of Environment and Water of Hungary to embark on a countrywide drought planning programme to coordinate drought planning efforts throughout the country, to ensure that available water is used efficiently and to provide guidance on how drought planning can be accomplished.
With regard to this plan, it is indispensable to analyze the regional drought frequency and duration in the target region of the programme as fundamental information for the further works. According to these aims, first we initiated a methodological development for simulating drought in a non-contributing area. As a result of this work, it has been agreed that the most appropriate model structure for our purposes using a spatially distributed physically based Soil-Vegetation-Atmosphere Transfer (SVAT) model embedded into a Markov Chain-Monte Carlo (MCMC) algorithm for estimate multi-year drought frequency and duration. In this framework:
- the spatially distributed SVAT component simulates all the fundamental SVAT processes (such as: interception, snow-accumulation and melting, infiltration, water uptake by vegetation and evapotranspiration, vertical and horizontal distribution of soil moisture, etc.) taking the groundwater table as lower, and the hydrometeorological fields as upper boundary conditions into account;
- and the MCMC based stochastic component generates time series of daily weather data for the multi-year simulation of SVAT processes.

In order to test the elaborated methods, a sub-area of the full domain has been designated as a pilot area for this study. Considering our aims, major achievements with respect to the objectives have been accomplished for the pilot area within the scope of this work includes:
- Harmonized 3D grid model to describe hydraulic properties of the unsaturated zone has been created (Pásztor, L. et al 2002 and 2005, Kuti, L. 2007);
- The spatially distributed physically based distributed parameter SVAT model DIWA (DIstributed WAtershed) (Szabó, J.A., 2007) has been adapted;
- The stochastic characteristics and parameters of the weather generator has been derived from measured data series;
- Coupling the stochastic weather generator with the deterministic DIWA SVAT-type model also has been done.

In this paper, the results of the coupled (deterministic - stochastic) model simulation based analysis of regional drought frequency and duration for a sub-area of the full domain of the Great Hungarian Plain will be reported.

First the harmonized 3D grid model of the hydraulic properties of the unsaturated zone will be presented. Then a brief characterisation of the DIWA model will be given. The Markov chain based stochastic weather generator also will be presented. Finally, the results of multi-year drought frequency and duration analysis at the pilot area and conclusions will be discussed.

Keywords:
Drought frequency and duration analysis; multivariate analyses; recurrence analyses; extreme events; stochastic weather generator; spatially distributed SVAT model; 3D grid model of hydraulic properties of the unsaturated zone.

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