Catena 141 (2016) 92–99

Contents lists available at ScienceDirect

Catena

journal homepage: www.elsevier.com/locate/catena

Drought-related variables over the Bârlad basin (Eastern Romania) under climate change scenarios

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ARTICLE INFO

Article history:
Received 6 August 2015
Received in revised form 12 February 2016
Accepted 23 February 2016
Available online 9 March 2016

Keywords:
Climate change
Eastern Romania
Palmer Drought Severity Index
EURO-CORDEX
Available water capacity of soils
Potential evapotranspiration

ABSTRACT

The goal of this study is the assessment of the future evolution of monthly temperature and precipitation and their influences exerted on droughts occurring in the Bârlad river basin (Eastern Romania). We have used recent results of experiments based on regional and global climate models under the Representative Concentration Pathway (RCPs) scenarios (RCP 4.5 and RCP 8.5), which have been made accessible thanks to the EURO-CORDEX initiative. The impact of climate change on drought is assessed by using the Palmer Drought Severity Index (PDSI). The correlations between the observed streamflow at the Bârlad basin outlet and the PDSI-related indices show that the PDSI represents reasonably well the local water balance. The linear trend analysis of multimodel ensemble means reveals that, under climate change, the basin-averaged PDSI will be lower thus indicating a tendence towards drought. The PDSI method applied to the Bârlad basin seems to show low sensitivity to soil characteristics such as available water capacity when drought trends are investigated. On the other hand, model results reveal that, under climate change conditions, the Thornthwaite formula for calculating the potential evapotranspiration will lead to a substantial overestimation of the aridity tendence whenever compared with the Penman–Monteith approach. Depending on the specific climate scenario and parametrization of potential evapotranspiration, droughts that were deemed as incipient, mild or severe towards the end of the 20th century will have been a normal feature towards the end of the 21st century.

1. Introduction

The Bârlad catchment covers 16% of the Siret river basin — an important tributary of the Danube (Fig. 1). The main characteristic is the high homogeneity of the landforms, over 92% of the area illustrating the plateau morpho-structural unit. As a consequence, the mean elevation is of only 211 m, with a low standard deviation (88 m). A relative large area (45%) is characterized by low slopes. Usually, the snow melting and the rain provide the main supply for the surface waters in the Bârlad river catchment (Ujvari, 1972; Butelcă, 2012). In this context, the assessments of influences expected from changes in temperature and precipitation on the local water resources are important.

Climate impact assessments and local adaptation strategies require analysis based on numerical experiments using climate models with very high spatial resolution under scenarios of global climate change, and robust evaluation of the results within the limits of reasonable uncertainty. For now, no detailed analysis of climate change projections in the Bârlad basin has been done, taking into account the new scenarios assessed within the Fifth Report of the Intergovernmental Panel on Climate Change (IPCC, 2013). The main purpose of this study is the assessment of the current and future climate conditions that will affect the droughts in the Bârlad basin by using recent results made available thanks to the European component of the COordinated Regional Climate Downscaling Experiment (EURO-CORDEX) program (Jacob et al., 2014). These results are based on regional climate experiments under the Representative Concentration Pathway (RCPs) scenarios (van Vuuren et al., 2011).

We use here the Palmer Drought Severity Index (PDSI) to analyze the droughts (Palmer, 1965). The observations of soil moisture (directly related to droughts) are limited in space and time. Therefore, the use of available data to build soil moisture-related indices is a pragmatic approach. On the other hand, in the climate models, errors in initializing

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http://dx.doi.org/10.1016/j.catena.2016.02.018

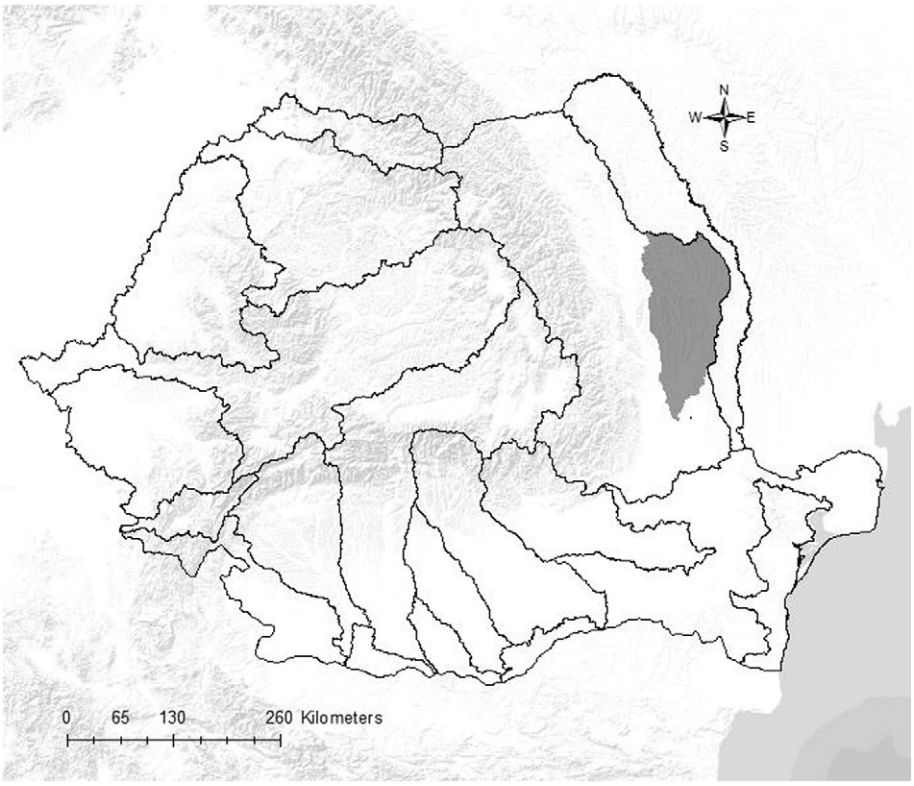

Fig. 1. Location of the Bârlad catchment (dark gray area). Contour lines illustrate the Romanian hydrographic basins. Gray shades represent the topography.

and representing soil processes tend to cause errors in soil moisture prediction and projections. In this context, the PDSI provides a simple tool having the advantage to keep the drought metric close to the real world through the combination of climate variables easily available from the observation system, which are also relatively well simulated by the climate models (such as air temperature and precipitation).

2. Data and methods

In this study we have used monthly temperature and precipitation from observations and model results covering the Bârlad basin (which has the outlet at Tecuci gauging station). The results of the climate model used here have been derived under the RCP scenarios. The RCP scenarios describe temporal evolutions in the global concentrations of the greenhouse gases (GHGs) illustrating the radiative forcing within the period 2006–2100. For instance, the radiative forcing caused by increased levels of the GHGs reaches in the year 2100 a value around 4.5 (8.5) W/m^2 above the pre-industrial level in the RCP 4.5 (RCP 8.5) scenario (van Vuuren et al., 2011).

The recent CMIP5 results have a global coverage with horizontal resolutions of about 100 km, which are suitable for global and continental scale analysis. However, these resolutions are not appropriate for detailed characterization of the local processes like those taking place in river catchments such as the Bârlad basin. Therefore we use regional climate models from the COordinated Regional Climate Downscaling Experiment (CORDEX) driven by global models from the CMIP5. As part of CORDEX framework, EURO-CORDEX initiative provides regional climate projections for Europe at horizontal resolutions of around 50 km (EUR-44) and 12.5 km (EUR-11). In this study, we have extracted the available EURO-CORDEX results having very high resolution (EUR-11). Table 1 presents the regional and global climate models analyzed here.

A Romanian gridded dataset (ROCADA) provides observations of air temperature and precipitation amounts with a horizontal resolution of 10 km (Birsan and Dumitrescu, 2014a; Dumitrescu and Birsan, 2015). In our area of interest there are 5 meteorological stations but the interpolation method of kriging in space and time uses data from a larger number of locations, some of them are located nearby the edges of the Bârlad basin (about 12 stations).

We have spatially averaged the observed and simulated data across the basin of the Bârlad River and then compared them to validate the results from the models for the present time's climate (1971–2000).

Table 1
Regional and global climatic models used for assessing the influence of climate change on the future evolution of temperature and precipitation in the Bârlad basin.

No.	Regional climatic modeling center	Regional model	Global model
1	CLMcom (CLMcom Consortium)	CLM 4-8-17	MPI-ESM-LR
2	DMI (Danish Meteorological Institute)	HIRHAM5	ICHEC-EC-EARTH
3	KNMI (Royal Netherlands Meteorological Institute)	RACMO22E	ICHEC-EC-EARTH
4	MPI-CSC (Max-Planck Institute — Climate Service Center, Hamburg, Germany)	REMO2009	MPI-ESM-LR
5	SMHI (Swedish Meteorological and Hydrological Institute)	RCA4	ICHEC-EC-EARTH