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Spatial and temporal variability of winter streamflow over Romania and its relationship to large-scale atmospheric circulation

M. Ionita [a,*], S. Chelcea [b], N. Rimbu [c,d], Mary-Jeanne Adler [b]

[a] Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
[b] National Institute of Hydrology and Water Management, Bucharest, Romania
[c] University of Bucharest, Faculty of Physics, Bucharest, Romania
[d] Climed Norad, Bucharest, Romania

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SUMMARY

In this study we have examined the spatial and temporal variability of winter (DJF) streamflow over Romania as recorded at 46 hydrological stations over the period 1935–2010. An empirical orthogonal function analysis (EOFs) was employed to characterize the spatial variability of winter streamflow. The dominant mode captures in-phase variability of river flow anomalies over the entire country. The second mode is characterized by a north–south dipole, emphasizing the influence of topography over the streamflow variability. Both modes are related with large-scale atmospheric circulation and sea surface temperature patterns. We show that the Arctic/North Atlantic Oscillation, East Atlantic, East Atlantic/Western Russia and Scandinavian patterns control a significant part of the interannual winter streamflow variability as captured by these two modes. Moreover, we show that the winter streamflow is very sensitive to the influence of winter temperatures. Positive streamflow anomalies are recorded during warm winters, which are favorable to precipitation fallen as rain, while cold winters can favor snowy winters and frozen ground and hence reduced winter discharges.

1. Introduction

The availability of water resources is strongly influenced by climate conditions that vary on a wide range of timescales (e.g. seasonal, interannual and/or decadal to multidecadal). On seasonal timescales, anomalous atmospheric conditions are often linked with seasonal variations in the river streamflow, via variations in precipitation and temperature (Dettinger and Diaz, 2000; Cullen et al., 2002; Trigo et al., 2002). The interaction between river streamflow and low-frequency climate patterns has been studied for various hydrological systems all over the world (Dettinger and Diaz, 2000; Barlow et al., 2001; Barros et al., 2004; Ward et al., 2010). Two of the most important phenomena that influence streamflow variability are the North Atlantic Oscillation (NAO) and El Niño-Southern Oscillation (ENSO) (Dettinger and Diaz, 2000; Cullen et al., 2002; Rimbu et al., 2004). The indices of these two large-scale climatic patterns have been used as predictors for the seasonal streamflow anomalies over Europe (Trigo et al., 2002; Rimbu et al., 2004; Ionita et al., 2008). Correlations with hydrological data have shown that when NAO index is high river flow is above average in the northern part of Europe and below average in the southern part of Europe (Shorthouse and Arnell, 1997; Dettinger and Diaz, 2000). Another pattern that strongly influences the precipitation and streamflow over Europe is the East Atlantic/Western Russia (EA/WR) (e.g. Ziv et al., 2006).

Streamflow is an integrated response to climate, water transfer, evapotranspiration and the effect of human activities on the natural water flows. The response time of the streamflow to climate conditions depends strongly on the catchment area characteristics (e.g. geology, topography, soils and vegetation) and among different climatic regions (Post and Jakeman, 1996; Fleig et al., 2011). In the same time, the hydrological response to climate is also season dependent because the water resources, the climatic conditions and the hydrological processes vary throughout the year (Tallaksen, 1995; Garcia-Ruiz et al., 2008).

Romania is situated in the southern part of Europe and has a temperate continental climate. Various studies, focused over Romania, have shown certain changes in surface air temperature

* Corresponding author at: Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Bussestrasse 24, D-27570 Bremerhaven, Germany. Tel.: +49 4714831 1845; fax: +49 4714831 1271.
E-mail address: monica.ionita@awi.de (M. Ionita).

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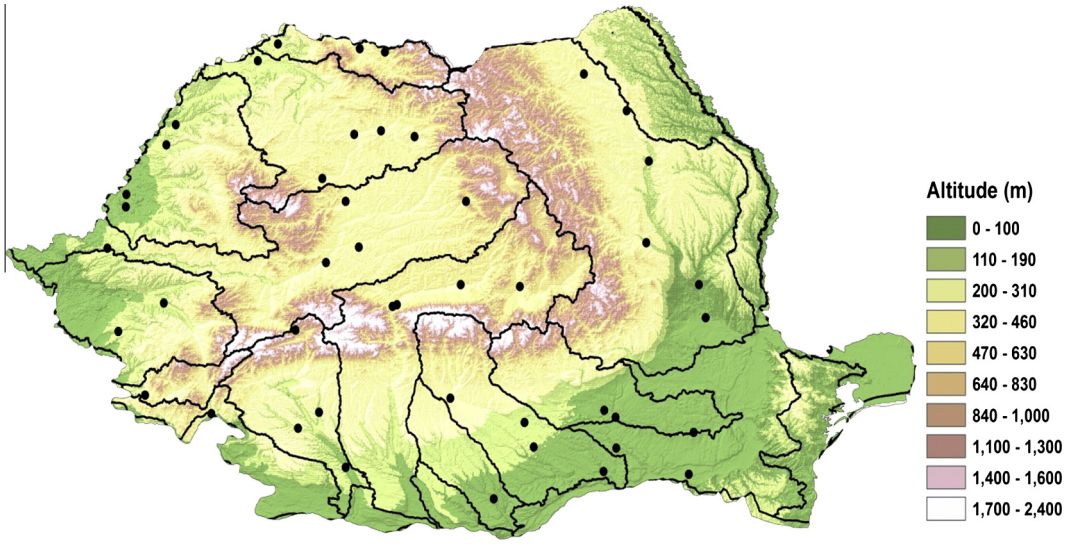

Fig. 1. The topographic map of Romania and the location of the stations used in this study.

and precipitation (Bojariu and Paliu, 2001; Tomozeiu et al., 2002, 2005; Ionita et al., 2013). The streamflow variability over this region has been studied only for small areas (Stefan et al., 2004) and for certain basins (Rimbu et al., 2004). The aim of this study is to analyze the spatio-temporal variability of winter streamflow variability over Romania and its relationship with large scale atmospheric circulation based on a country wide data network.

The paper is organized as follows: in Section 2 a short description of the data sets and the methods employed in this study is given. In Section 3 the main results are presented. The discussion and the main conclusions follow in Section 4.

2. Data and methods

The streamflow data series used in this study have been provided by the National Institute of Hydrology and Water Management (INHGA). The time series consist of monthly streamflow values recorded at 46 stations located over the whole Romanian territory (Fig. 1) and cover the period 1935–2010. The streamflow time series have continuous record and are quality controlled. To investigate the relationship of winter streamflow variability with global sea surface temperature we use the Hadley Centre Sea Ice and Sea Surface Temperature data set (HadISST, Rayner et al.,

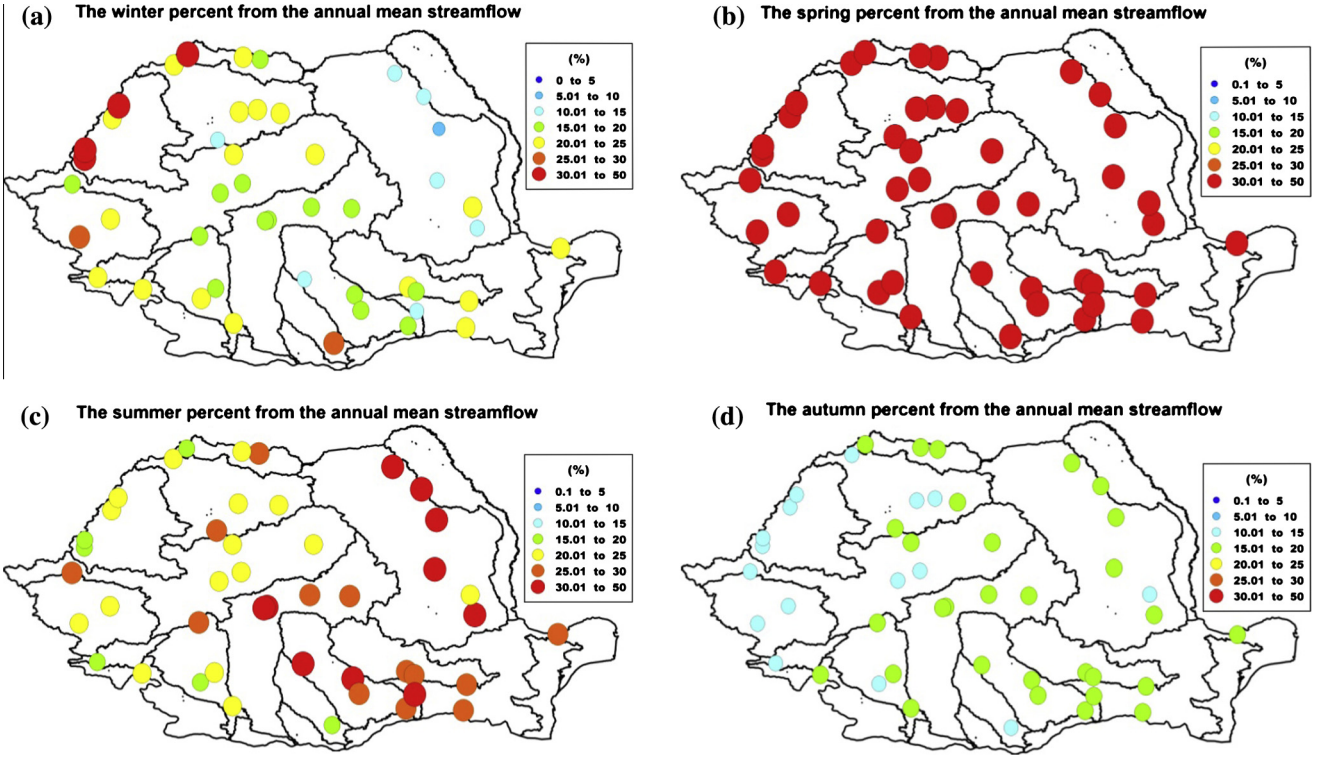

Fig. 2. The contribution (%) of (a) winter; (b) spring; (c) summer and (d) autumn streamflow to the mean annual streamflow for the 46 streamflow over Romania during 1935–2010 period.