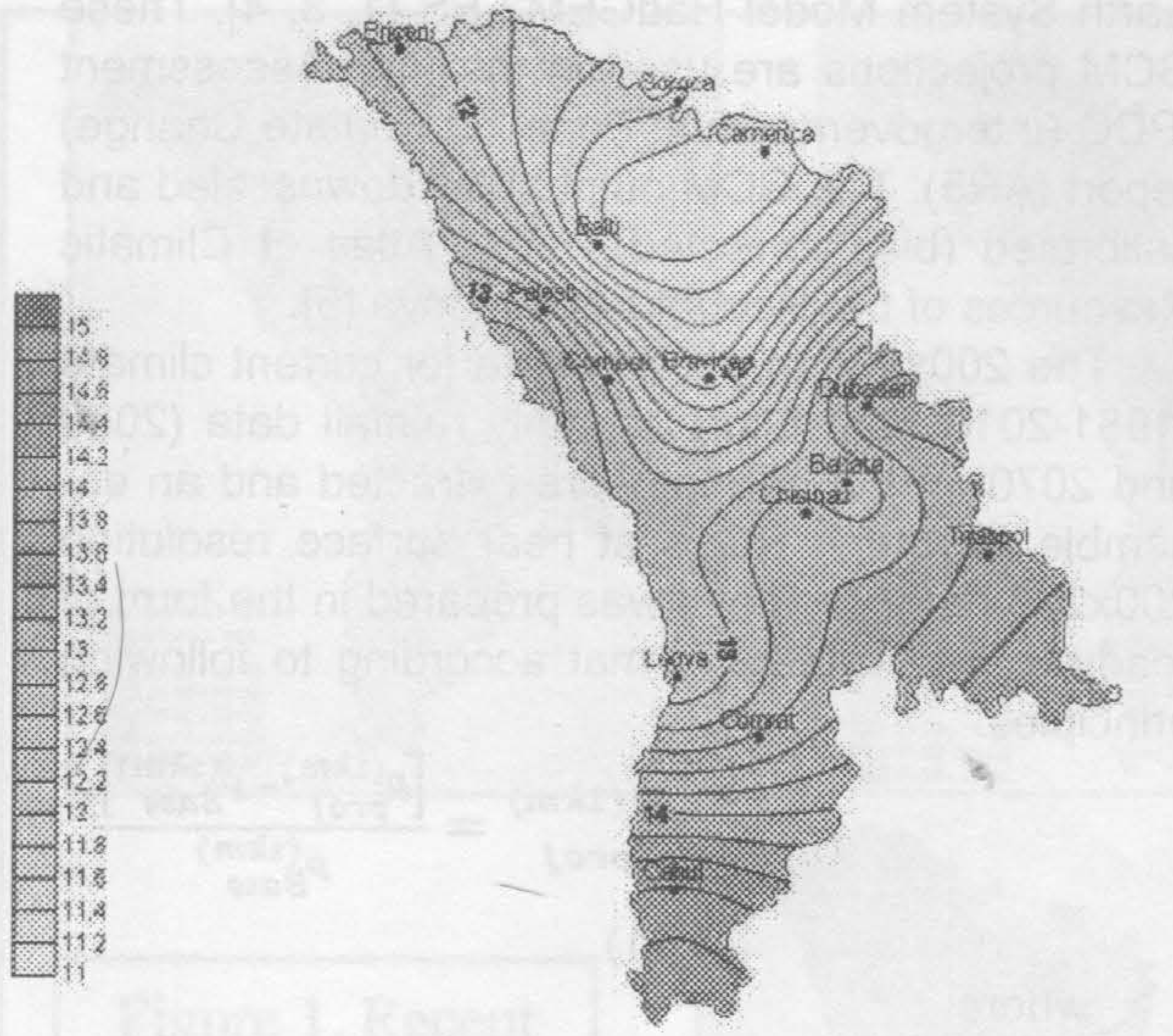

Fig. 5 Cartographic modelling of Climate Suitability Coefficient for grape quality. Case Study, 2013

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GEOGRAPHICAL INFORMATIONAL SYSTEMS AND CLIMATE PROJECTIONS IN THE REPUBLIC OF MOLDOVA

Jeleapov Ana[1], Rawat Monica[2], Raileanu V.[3], Nedealcov Maria[3], Sena D. R.[4]

[1]Laboratory of Landscape Ecology, Institute of Ecology and Geography of Academy of Sciences of Moldova

[2] Uttarakhand Open University, Nainital, Uttarakhand, India

[3]Laboratory of Climatology and Enironmental Risks, Institute of Ecology and Geography of Academy of Sciences of Moldova

[4]Central Soil and Water Conservation, Research and Training Institute, Dehradun, India

Abstract. Presented article contains first attempt to evaluate modification of monthly sums of precipitation in the limits of Moldova under influence of future climate conditions. Initialy, climate projection database from global climate models (GCMs) for four representative concentration pathways (RCPs): 2.6, 4.5, 6.0 and 8.5 have been generated for the territory of the Republic of Moldova using the recent Coupled Model Intercomparison Project 5 (GMIP5), a coupled Earth System Model HadGEM2-ES. These climate projections are the GCM projections used in the Fifth Assessment IPCC report. The GCM was downscaled and calibrated using the maps for a monthly sum of precipitations generated using the database from climate stations and posts of the State Hydromeorological Service of Moldova for the period 1981-2010. Based on generated maps the monthly sums of precipitation were calculated for two main projected periods 2050 (average of 2040-2060) and 2070 (average of 2060-2080) for all administrative districts of the Republic of Moldova. Analysis of modeled data shows that modifications are characteristic for all months: substantial reduction being for July and August and relative increases being for October-May. The results of climate change projections can be utilized for generating bio-climatic variables and evaluation of future water resources essential to define agricultural scenarios in Moldova as affected by climate change.

Keyword: CMIP5, HadGEM2-ES, RCPs, Climate Change, DIVA-GIS

1 *Contact information:* Ana Jeleapov, Laboratory of Landscape Ecology, Institute of Ecology and Geography of Academy of Sciences of Moldova, Academiei str., 1, MD 2028, Chisinau, Republic of Moldova, e-mail: anajeleapov@gmail.com, tel. (+373) 68473729

Introduction

The Republic of Moldova is an agricultural country. Its exposure to climate changes increases the vulnerability for safe and sustainable development of agriculture. Climate changes over the past 25 years have been manifested by sudden increase of frequency and amplitudes of temperature and precipitation extremes which caused tremendous damage to the national economy. Some forecasts show that climate change will increase in the future. In this context the main goal is to assess the future climate conditions in order to develop action plans for adaptation and mitigation of climate change. Utilization of global and regional climate models (GCMS, RCMS) and development of climate projections, especially recent projections (GMIP5, HadGEM2-ES) will contribute to achieve this goal. Present study contains the results of modeling of monthly sums of precipitation basing on climate changes projections from 5th IPCC report for two projected periods: 2050 and 2070.

Material and methods

The precipitations have a dynamic character and a high variability in space. First attempt for creating precipitation maps for territory of the Republic of Moldova was made in 2013 through creating the Atlas of Climatic Resources of the Republic of Moldova [5]. The atlas contains a set of thematic maps reflecting the spatial distribution of monthly, seasonal, and annual mean air temperature, the average amount of monthly, seasonal and annual precipitations for a period of 30 years (1981-2010). The data recorded from meteorological stations and posts of State Hidrometeorological Service served as starting material. All maps were developed at scale 1:1500000 in Universal Transversal Mercator projection (UTM), using cartographic modeling. Collected data correspond to meteorological shelter height (2 m).

Cartographic modeling was performed in two stages. At the first stage the method of multiple regression with step procedures was used, that allowed highlighting the values that reflect the temperature and rainfall dependence of several local physical-geographical factors. As indicators of model validation were used: the test of significance of each physical-geographical factor taken separately and that of the entire model, the coefficient of determination, the standard error of estimation, and the mean absolute error. At the second stage, the residuals of regression, which are determined by unknown factors, were interpolated using a local interpolator. The results of the interpolations were summed with the results of the regression model. The interpolators take into account only the data neighboring with the interpolated point.

Climate projection database from global climate models (GCMs) for four representative concentration pathways (RCPs 2.6, 4,5, 6,0 and 8,5) have been generated for Moldova using CMIP5 (Coupled Model Inter-comparison Project 5) centennial simulation carried out by Met Office Hadley Centre, a Coupled Earth System Model HadGEM2-ES [1, 3, 4]. These GCM projections are used in the Fifth Assessment IPCC (Intergovernmental Panel on Climate Change) report (AR5). The GCM output was downscaled and calibrated (bias-corrected), using Atlas of Climatic Resources of the Republic of Moldova [5].

The 200x200 m gridded data for current climate (1981-2010) and future monthly rainfall data (2050 and 2070) in GIS format were extracted and an ensemble for the 4 RCPs at near surface resolution 200x200 m for Moldova was prepared in the form of ready to use climate format according to following principles:

$$C_{proj}^{(1km)} = \frac{\left[P_{proj}^{(1km)} - P_{Base}^{(1km)}\right]}{P_{Base}^{(1km)}} \quad (1)$$

where:

$C_{proj}^{(1km)}$ = is the fraction of the relative change in monthly precipitation in projected period with respect to base period projection

$P_{Base}^{(1km)}$ = represents monthly precipitation data derived at a spatial resolution of 1 km X 1 km for the base period (1950-2000) [2].

$P_{proj}^{(1km)}$ = is monthly precipitation data derived at a spatial resolution of 1 km X 1 km for the projected period, downscaled global climate model (GCM) data from CMIP5 (IPPC Fifth Assessment) 2050 (2040-2060) or 2070 (2060-2080) [2] for different RCPs.

$C_{proj}^{(1km)}$ is converted to low resolution iso-C maps after applying appropriate spatial interpolation technique using Arc GIS and re-sampled and gridded to 200 m spatial resolution and grid values were represented as $C_{proj}^{(200m)}$. The projected precipitation data at 200mX200m resolution is therefore, derived using the formula

$$P_{proj}^{(200m)} = P_{Base}^{(200m)} * C_{proj}^{(200m)} + P_{Base}^{(200m)} \quad (2)$$

where,

$P_{Base}^{(200m)}$ =high resolution monthly precipitation maps downscaled and calibrated (bias-corrected), using Atlas of Climatic Resources of the Republic of Moldova (Nedealcov et al., 2013)

The procedure was uniformly adopted to create the layers of precipitation for the projected period 2050 and 2070 in all RCPs i.e. RCP 2.5, 4.5, 6.0 and 8.5 (fig. 1, 2, 3). The climate files (.clm files) were prepared using DIVA-GIS interface.

Results and discusions

Climate change modeling was performed for sums of precipitation for all months of the year for two main projected periods 2050 (average of 2040-2060) and 2070 (average of 2060-2080). Changes are characteristic for all months of the year. During the year there can be highlighted both reductions

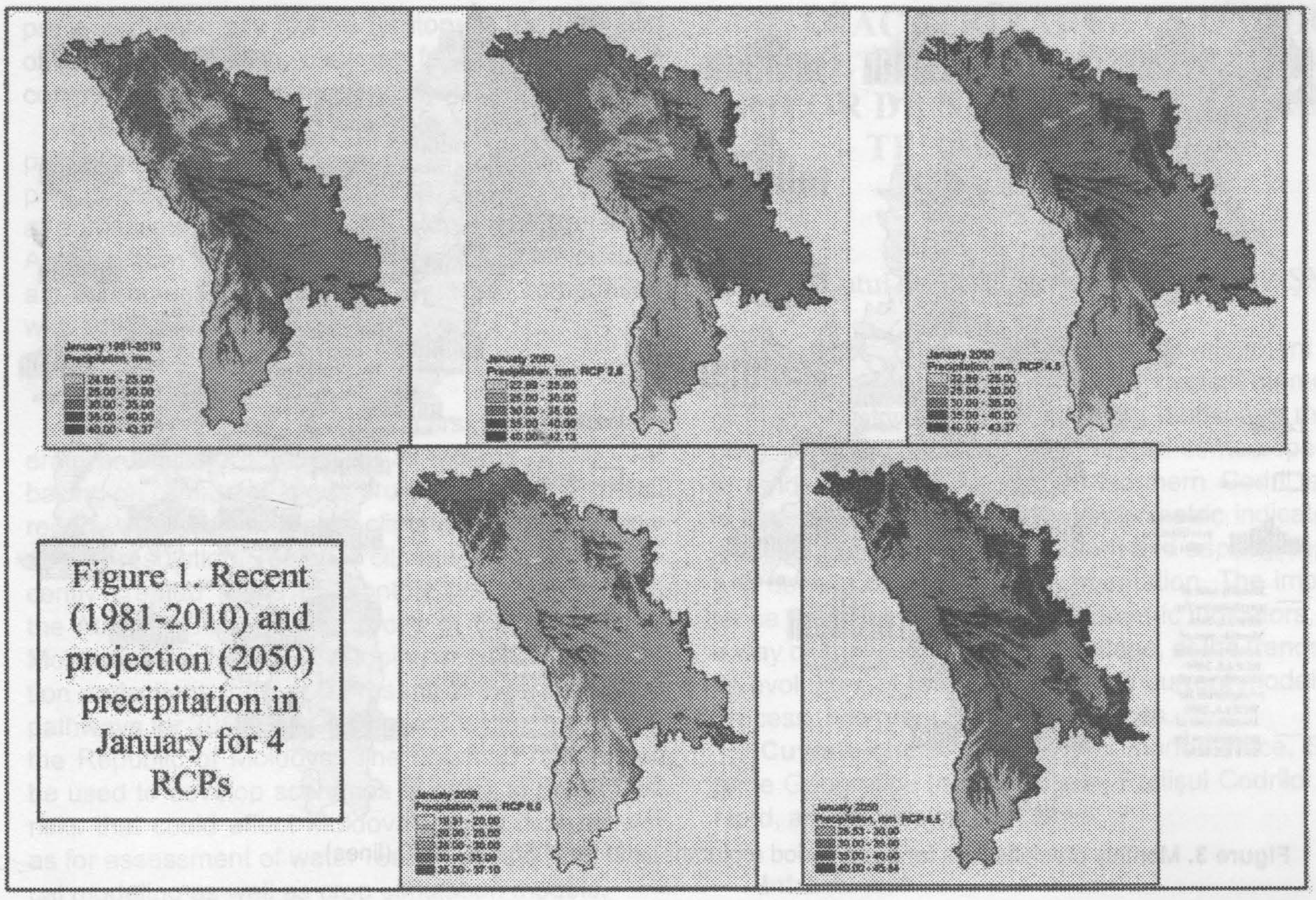

Figure 1. Recent (1981-2010) and projection (2050) precipitation in January for 4 RCPs

Figure 2. Recent (1981-2010) and projection (2050) precipitation in July for 4 RCPs

and increases in monthly sums of precipitation. Significant decreases in monthly sums of precipitations are observed during warm period and especially for July-August when reductions (for July) are in the limits of -1.16% (RCP 2.6, 2050) and -43% (RCP 8.5, 2070). Precipitation increases are observed during autumn and spring. In January there are observed changes in rainfall from -1.6 to + 24%. Figures 1 and 2 represent the grids for July and January for both the base period (1981-2010) and for 2050 period. Also, in fig. 4 and tab. 1 the averages for the same periods as well as 2070 period for all months of the year are

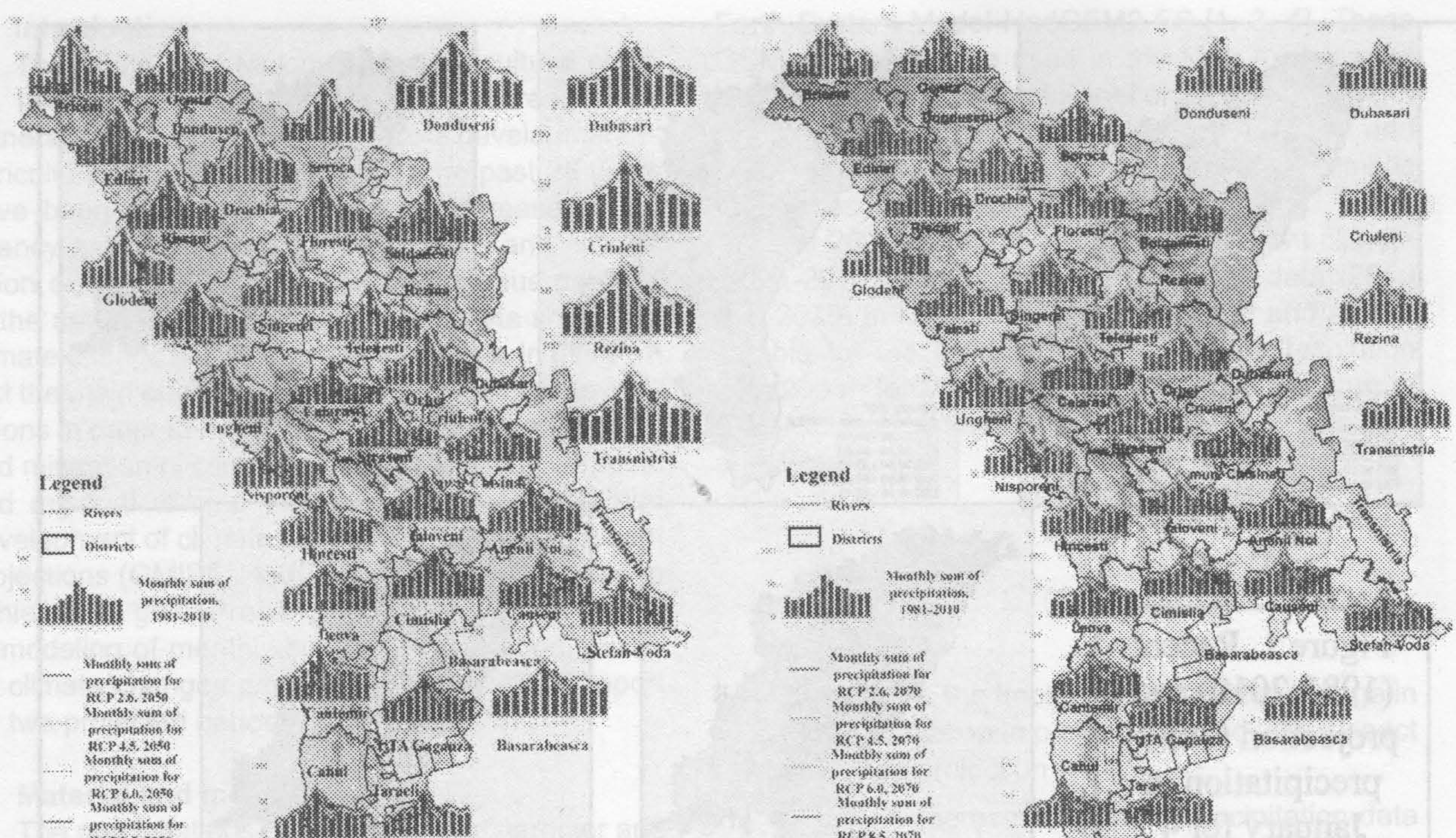

Figure 3. Monthly precipitations for base period (columns) and for 2050 and 2070 (lines)

Table 1. Sums of precipitation for all months of the year for different periods

Months	Base period 1981-2010	Period 2050 (2040-2060)				Period 2070 (2060-2080)			
		RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
January	31.5	31.0	32.2	27.6	33.6	33.0	32.1	33.0	39.2
February	28.8	33.9	35.5	32.9	28.9	33.5	36.5	32.4	40.1
March	29.7	32.7	35.3	36.1	35.8	34.4	36.1	36.7	38.1
April	40.1	42.2	46.5	41.0	45.9	43.7	46.4	45.7	45.4
May	51.3	59.4	56.9	57.9	55.6	56.8	50.7	57.1	54.8
June	75.1	81.0	76.7	83.8	73.7	84.9	74.1	67.7	60.2
July	69.8	69.0	49.3	53.9	44.7	59.3	51.9	46.5	39.8
August	53.3	36.4	33.5	40.4	30.2	41.5	36.0	32.2	24.0
September	52.0	44.2	46.3	42.4	53.0	52.4	49.4	51.0	33.1
October	35.4	45.7	45.8	43.3	45.0	38.6	43.0	44.8	45.3
November	36.7	39.7	35.8	38.7	42.2	38.8	40.9	41.5	39.8
December	34.9	37.9	32.2	35.9	35.8	39.3	37.7	39.9	37.1
Annual	539	553	526	534	524	556	535	528	497

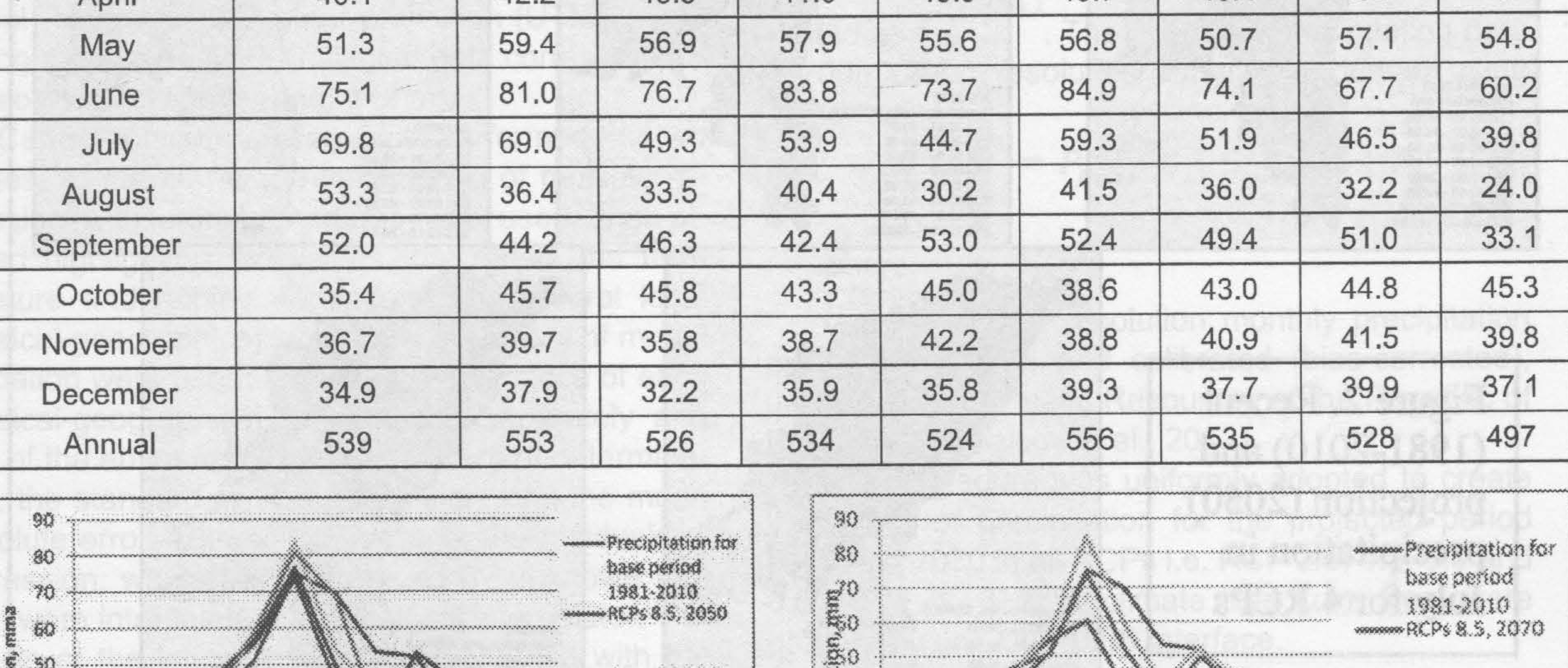

Figure 4. Comparison between monthly precipitations for base period and for projected periods

presented generally for the territory of the Republic of Moldova. As seen, changes for the period 2070 compared to 2050 are more obvious.

Based on generated maps the monthly sums of precipitation were calculated for two main projected periods 2050 (2040-2060) and 2070 (2060-2080) for all administrative districts of the Republic of Moldova. As seen from fig. 3 higher differences of precipitation are characteristic for northern district in comparison with southern.

Conclusion

This research represents the first attempt to generate precipitations maps for all months of the year basing on climate changes projections from 5th IPCC report. Utilization of global climate models with low spatial resolution, regional climate models and recently created maps of monthly precipitation from the Atlas of Climatic Resources of the Republic of Moldova [5] allowed developing regional precipitation projections for four representative concentration pathways for 2050 and 2070 years for the territory of the Republic of Moldova. The obtained results can be used to develop scenarios in order to predict the risks that could affect Moldova's agriculture as well as for assessment of water resources and hydrological modeling as well as crop simulation models.

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CARACTERIZAREA GEOMORFOMETRICĂ A PODIŞULUI CODRILOR DE NORD ŞI UTILIZAREA TEHNICILOR SIG

Viorica Angheluţa

Institutul de Ecologie şi Geografie al AŞM

Abstract: In recent times the development of GIS applications has represent an important moment of practical significance concerning landscape morphometric analysis. This paper shows some aspects of landscape morphometry of Northern Codrii and is based on the analysis of morphometric indicators such as: elevation, slope gradient and aspect, depth and density of landscape fragmentation. The importance to calculate these morphometric indicators, as a way of knowledge of the landscape, of the trends of its evolution, of the intensity of the current modeling process, has great practical valences.

Cuvinte-cheie: caracteristici morfometrice, Sisteme Geografice Informaţionale, Podişul Codrilor de Nord, analiza spaţial cantitativă

Introducere

Spaţiul delimitat de Podişul Codrilor de Nord reprezintă o unitate geografică complexă din punct de vedere morfometric, respectiv al altitudinii, declivităţii, fragmentării şi expoziţiei diferitelor forme de relief. Analiza particularităţilor morfometrice (hipsometrie, fragmentarea reliefului, geodeclivitate), ajută la înţelegerea aspectelor de ordin genetic, iar variaţia valorică a acestor indicatori sintetici sugerează dimensiunea potenţialului evolutiv de care dispune un sistem teritorial. De asemenea, relevarea caracteristicilor morfometrice conduce la evidenţierea intensităţii proceselor actuale de morfogeneză şi impun încadrarea formelor de relief în tipologii şi clase ierarhice. În acest context, scopul acestei lucrări constă în caracterizarea indicatorilor morfometrici ai reliefului din cadrul Podişului Codrilor de Nord pe baza Modelului Numeric al Terenului (MNT).

Materiale şi metode

Metodologia aleasă pentru analiza caracteristicilor morfometrice se bazează pe conceptele GIS de realizare şi analiză spaţială a bazelor de date datorită faptului că acurateţea şi calitatea rezultatelor finale este net superioară. Utilizarea sistemelor informaţionale geografice reprezintă o nouă modalitate de a vizualiza, gestiona informaţii, analiza relaţii şi procese corelate cu spaţiul geografic, colecta, stoca, analiza, vizualiza, edita şi afişa datele geografice [4]. Printr-o corelaţie hardware, software şi proceduri s-au realizat analize geomorfometrice complexe pe baza datelor raster, vector şi de tip grilă (reţeaua hidrografică, MNT), cu ajutorul cărora s-au derivat indicatorii morfometrici principali (declivitatea terenului, orientarea versanţilor, adâncimea fragmentării reliefului sau energia reliefului şi densitatea fragmentării reliefului),