ESTIMATION OF THE CLIMATE CHANGE OF EVAPORATION IN OSAM RIVER BASIN

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Abstract

Water is essential for life and water problems are strictly related to the present and future living conditions in the world. One of the principal aspects of present and future water problems is the rational utilization of the existing surface and underground resources, in order to satisfy the demand that is strictly connected to all the intrinsic aspects of human living and civilization.
Climate changes are directly related to water resources, which are of high socio-economic and environmental significance. The aim of presented work is to analyze the trends in the evapotranspiration time series. The data from four meteorological stations situated in Osam river basin are used. The Spearman and Man-Kendall tests are applied. In the paper the expected values of actual evapotranspiration for the years 2025, 2050 and 2100, obtained on the basis of the results from HaDCM3 and ECHAM4 climate change scenarios are given as well.

1 INTRODUCTION

The watershed of the Osam river is situated in middle Danube plain and coincide with a part of Moderate – Continental Climatic sub region (Fig.1) (Sabev at all 1959). The Osm river spring from the Central part of Balkan (Stara planina) mountain at 1821 m a.s.l. and run Northern crossing Danube plain and flow into Danube river at 20 m.a.s.l.
Hydrograph characteristics:

- Length = 314 km.
- Catchments area 2824 km^2
- Mean slope of the river is 57‰
- Mean river’s network density 0.4 km/km^2
- Coefficient of convolution 3.1

The river basin crosses four climatic regions in Bulgaria, all pertaining to the continental climatic subzone. A characteristic specificity of this climatic subzone is a well expressed summer maximum of precipitation and a minimum in the cold half-year.

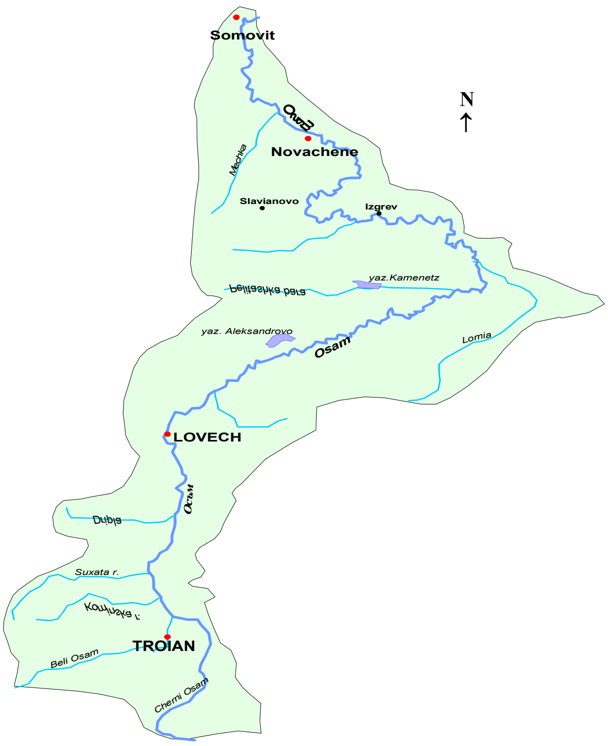

Fig.1. Scheme of Osam river basin

About 79 small reservoirs with total volume of 40147,3 x10^3 m^3 have been built on the Osam river basins.

2 METHODS AND DATA

Two methods were chosen to determine the potential evapotranspiration (PET):

- Thornthwaite (1948) method

$$PET_{TH} = 16^*\left(10\frac{T_M}{I_C}\right)^a \qquad (1)$$

$$I_C = \sum_{1}^{12}\left(\frac{T_{Mi}}{5}\right)^{1.514}$$

A = 0.01792*I_C + 0.4924
T_M - monthly average temperature

- Version of Eagelman (1967) formula

$$PET_{EG} = VM^*E^*(0.63+0.024TM)^*(100-F)^{0.5} \qquad (2)$$

Vm – average monthly wind speed
Tm – average monthly air temperature
f – relative humidity

The actual annual evapotranspiration is determined by the Turc (1954) formula

$$ET_{TR} = \frac{P}{\left(c + x^2\right)^{0.5}} \qquad (3)$$

x = P / EPI
EPI = 300 + 25*T + 0.05*T^3
P – sum of annual precipitation
T – mean annual temperature

The analysis of the evaporation regime is conducted based on the data from the stations of the National Meteorological Network as follows: Borima, Troian, Lovech, Novachene and Svishtov

The time series of the potential evapotranspiration (PET) obtained by different methods and actual evapotranspiraion have been analyzed for existence of long-term variability. The significance of the trends is estimated using Spearman and Man-Kendall tests. The developed by V. Alexandrov climate change scenarios (HadCM2 and ECHAM4 GCMs models) were applied to the 1961-1990 normal for seasonal and annual climate values of air temperature and precipitation in eight locations for selected hydrological region.

3 RESULTS

The results obtained by Spearman and Man-Kendall tests for PET are given in tables 1 and 2.

Tabl. 1. Estimation of the significance of the trends of PET_{TH}

Characteristic	Mann-Kendal K (sig. >0.19)	Spearman (sig. >2.0)
Novachene		
Year	**0.24**	**2.55**
Winter	0.08	1.25
Spring	-0.01	-0.1
Summer	0.16	1.27
Autumn	-0.09	-0.88
Somovit		
Year	**0.23**	**2.85**
Winter	0.18	1.9
Spring	0.18	1.8
Summer	**0.21**	**2.59**
Autumn	-0.09	-1.7
Troian		
Year	0.11	1.42
Winter	0.13	1.52
Spring	0.00	0.06
Summer	**0.21**	**2.25**
Autumn	**0.2**	**2.8**
Lovech		
Year	**0.24**	**2.46**
Winter	0.06	0.68

Spring	0.06	0.48
Summer	**0.21**	**2.49**
Autumn	-0.16	-1.48

As it can be seen in the lower part of Osam river there is a significant trends of increasing of the yearly sums of PET_{TH}. The same tendency is observed in the summer sums for Somovit, Troian and Lovech.

Table 2. Estimation of the significance of the trends of annual PET_{EG} – Osam River

Characteristic	Mann-Kendal K (sig. >0.19)	Spearman (sig. >2.0)
Troian	-0.14	-0.92
Lovech	**0.20**	**2.8**
Novachene	**-0.22**	**-2.2**
Somovit	**-0.23**	**-2.29**

In case of using Eagelman’s approach the significant positive trend appears only for station Lovech. The different trends in PET_{EG} along the river can bee explained with decreasing of the wind speed caused by growth of the threes and urbanization of the area of in stations Novachene and Somovit.
The results for actual evapotranspiration (ET) are given in tab.3

Table 3. Estimation of the significance of the trends of annual ET – Osam River

Characteristic	Mann-Kendal K (sig. >0.19)	Spearman (sig. >2.0)
Troian	0.06	0.6
Lovech	0.03	0.31
Novachene	-0.03	-0.3
Somovit	-0.01	-0.1

The absence of the significant trend in ET could be result of the opposite trends in temperatures and precipitation.
The output data from HadCM2 has been applied for calculation of the possible annual and seasonal evapotranspiration for years 20025, 2050 and 2100. The results are shown in table 4and fig.2

Table.4.The possible annual and seasonal PET_{TH} according the climate change scenarios

Years	**Troian**		**Lovech**		**Novachene**		**Somovit**		**Areal**	
61-90	740		797		830		838		744	
Models	**HadCM2**	**ECHAM4**	**HadCM2**	**ECHAM4**	**HadCM2**	**ECHAM4**	**HadCM2**	**ECHAM4**	**HadCM2**	**ECHAM4**
2025	779	787	833	843	880	892	886	899	785	796
2050	816	834	875	896	926	951	933	962	823	845
2100	911	955	984	1038	1044	1112	1054	1131	918	973

As can be seen in table 4 according the both models scenarios during the 21 century in basins the increasing of PET_{TH} is expected. For yearly PET_{TH} this increasing is more obvious according **ECHAM4**.
This increasing is strongly expressed during the warm part of the year reaching in Jun according HadCM2 is about 7% for 2025, 15%r 2050 and 34%for 2100 for areal

PET_{TH} of the investigated river, and according ECHAM4 the expected change is respectively 7%, 14% and 33% (fig. 2).

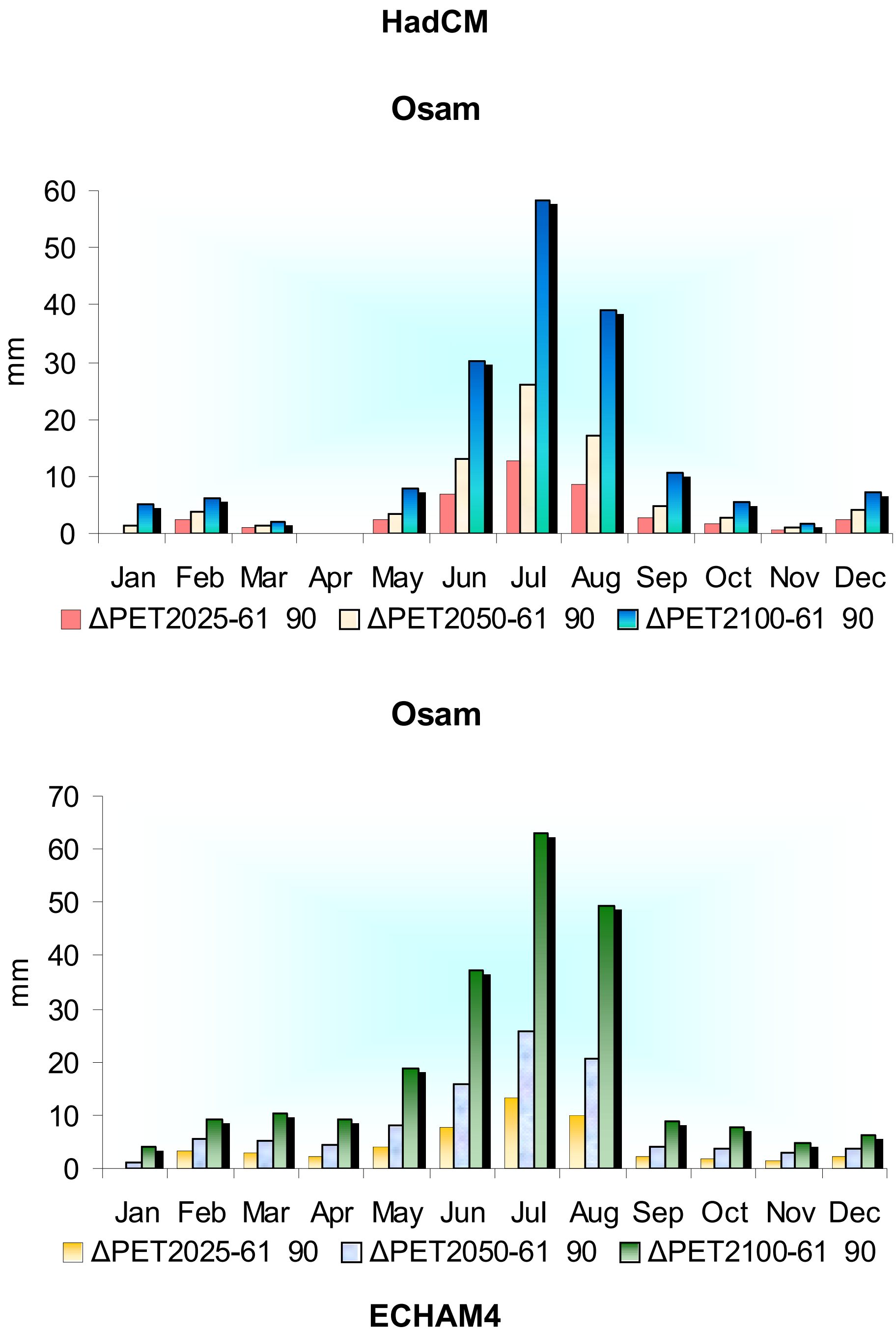

Fig.2. The expected differences of areal PET_{TH} in respect to the 1961-1990 normals in accordingt to the models HadCM and ECHAM4

In contrary with PET_{TH} according the climate change scenarios HadCM2 it is not expected considerable and uniform change in actual evapotranspiration in the investigated locations (tabl.5 and fig.3). Concerning the areal ET for Osam river insignificant increase (until 5mm) is expected to 2050 and decreasing in the end of century.

Table 5. The possible annual ET according the climate change scenarios

Years	Troian		Lovech		Novachene		Somovit		Areal	
61-90	476		455		421		424		462	
Models	HadCM2	ECHAM4	HadCM2	ECHAM4	HadCM2	ECHAM4	HadCM2	ECHAM4	HadCM2	ECHAM4
2025	485	494	459	466	421	427	423	429	467	475
2050	490	507	459	474	419	431	420	433	469	485
2100	491	532	452	485	409	435	409	434	466	501

The ECHAM4 models give different tendencies of change of ET during the century. The slight positive trend (les than 10%) of ET is found out.

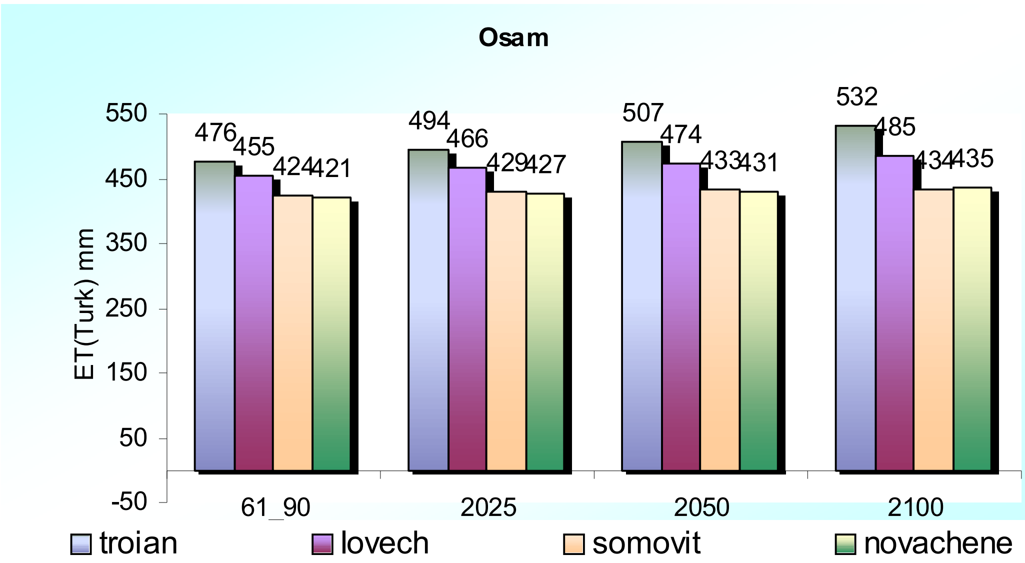

Fig.3. The expected ET according ECHAM4 for the years 2025, 2050 and 2100 in comparison with the 1961-1990 normal

The expected changes of the potential evapotarnspiration presented in percent are given in table 6.

Table 6. The expected PET_{TH}

HadCM2 ΔPET%

Stations	2025	2050	2100
Troian	5	10	23
Lovech	5	10	23
Novachene	6	12	26
Somovit	6	11	26
Areal	5	11	23

ECHAM4 ΔPET%

Years	2025	2050	2100
Troian	6	12	29
Lovech	6	12	29
Novachene	7	15	34
Somovit	7	15	35
Areal	7	14	31

The expected changes of the actual evapotarnspiration presented in percent are given in table 7.

Table 7. The expected ET

HadCM2 ΔET%

Stations	2025	2050	2100
Troian	2	3	3
Lovech	1	1	-0.6
Novachene	0	-0.5	-3
Somovit	-0.2	-0.9	-3
Areal	1	1.5	0.9

ECHAM4 ΔET%

Years	2025	2050	2100
Troian	4	7	12
Lovech	2	4	7
Novachene	1	2	3
Somovit	1	2	2
Areal	3	5	8

4 CONCLUSIONS

The completed study does not claim to exhaust the subject. However, some conclusions can be drawn concerning the regime of the potential and actual evapotranspiration in the Osam Rriver basin:

1. In the investigated river basin the significant increasing trend of potential evapotranspiration appears.
2. The both climate change models give very close values of expected potential evapotranspiration during 21 century.
3. In contrary with PET_{TH} the used climate change scenarios give different tendencies for expected ET, without uniform change in different stations. The reason for that are the different values of expected precipitations.

References

Eagleman, J.R., (1967). Pan evaporation, Potential and Actual Evaporation. *Journal of Applied Meteorology*. volume 6. number 3. pp.482-488.

L. Sabev and Sv. Stanev, 1959, Climate regions of Bulgaria and their climate, Annals of National Institute of meteorology and hydrology, Sofia vol. V

Thorthwaite, C. W., (1948). An approach toward a rational classification of climate. *Geog. Rev*. 38, p.p.55-94.

Turk, L., (1954). Le bilad'eau des sols: relation entre les precipitation l'evaporation et l'ecoulement. Annales Agronomiques, N4, p.p.491-595.