STUDY OF REFERENCE EVAPOTRANSPIRATION IN DOBROGEA REGION

STUDIU ASUPRA EVAPOTRANSPIRAȚIEI DE REFERINȚĂ ÎN DOBROGEA

MAFTEI CARMEN, GHERGHINA CRISTINA, GELMAMBET S., TEODORESCU D.

Ovdius University of Constanta and ANAR Dobrogea-Litoral

Abstract. *Accurate estimation of regional evapotranspiration (ET) is essential for many agricultural water related studies. The data from 10 weather stations, with at least 40 years of data during the period of 1965–2005, were used for estimation of reference ET (ET_0) in Dobrogea region. Two main objectives of this study were: (i) prediction of mean monthly and annually ET_0 in Dobrogea using the adjusted Thornthwaite method, and (ii) study of spatial variation of multi-annual ET_0.*

Rezumat. *Determinarea cu precizie a evapotranspiratiei este esentiala pentru cele mai multe din proiectele de irigatii. Pentru estimarea evapotranspiratiei de referinta, sunt utilizate datele de la 10 statii climatice din Dobrogea, pe aproximativ 40 de ani din perioada 1965-2005. Doua obiective sunt urmarite in acest studiu: (i) calculul medii lunare a evapotranspiratiei de referinta utilizand metoda Thornthwaite ajustata si (ii) studiul variatiei spatiale a evapotranspiratiei de referinta multi anuale.*

Evapotranspiration (ET) is the loss of water to the atmosphere by the combined processes of evaporation from the soil and plant surface and transpiration from plants (1). Estimation of evapotranspiration is one of the major hydrological components for determining the water budget. Quantification of referable reference evapotranspiration (ETo) for short grass is necessary in the context of many issues, for example, crop production, management of water resources, scheduling of irrigation, evaluation of the effects of changing land use on water yields, and environmental assessment (5).

MATERIAL AND METHODS

Dobruja or Dobrudja (Dobrogea in Romanian) is a region situated in the South – East of Romania, between the Black Sea and the lower Danube River (Fig.1). Generally, Dobrudja's climate is temperate - continental and is divided in 2 units (Fig.1): a units (I) which contain the Danube Delta, its south, the too lagoons (Razim lake and Sinoe lake) and the eastern region and another units (II) which contain the rest of territory while the climate is influenced by the moderate continental belt. Three general approaches to estimating reference ET_0 exist: temperature methods, radiation methods and combination methods. The temperature methods are empirical equations that rely on air temperature as a surrogate for the amount of energy that is available to the reference for evapotranspiration.

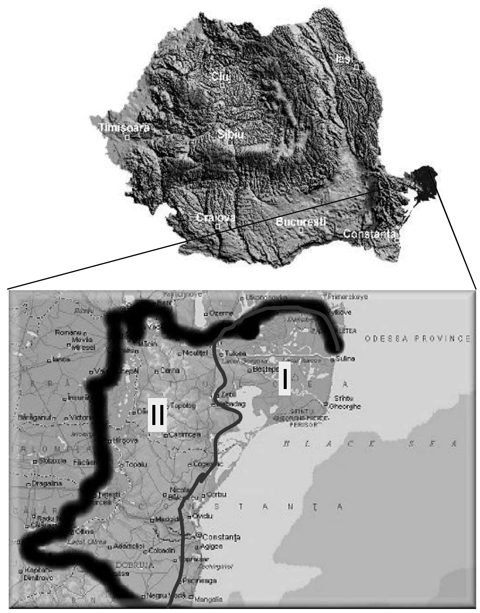


Fig.1 – Dobrudja region

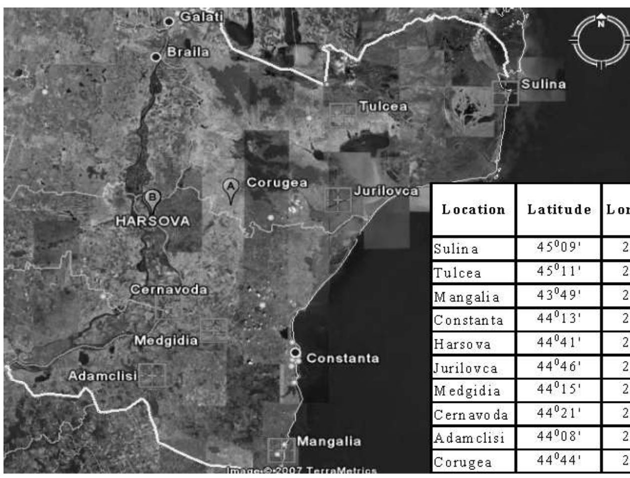
Thornthwaite (1948) developed an empirical equation for estimating potential evapotranspiraion from a reference grass surface that requires only mean monthly temperature and day length estimates as input. The regression equation was developed using data from lysimeter and small watershed water balance experiments at several sites scattered throughout the United States. Thornthwaite recognized that there is a more direct physical relationship between potential evaporation and net radiation than between potential evaporation and temperature, but foresaw correctly that sufficient radiation measurements or accurate calculations to reliably estimate potential evaporation would be difficult to come by for many years to come. The formula used by Thornthwaite is: $\boldsymbol{ET_o} = 16 \cdot \left(\frac{10 \cdot \boldsymbol{t}}{\boldsymbol{I}} \right)^{\boldsymbol{a}}$ where: where ***t*** is mean surface air temperature in month i (°C) and ***I*** is the heat index defined in equation below. The exponent ***a*** in is a function of the heat index (***I***).

$$\boldsymbol{I} = \sum_{\boldsymbol{i}=1}^{12} \boldsymbol{i}, \quad \boldsymbol{i} = (\boldsymbol{t}/5)^{1.514},$$

$$\boldsymbol{a} = 6.7 \cdot 10^{-7} \cdot \boldsymbol{I}^3 - 7.71 \cdot 10^{-5} \cdot \boldsymbol{I}^2 + 1.79 \cdot 10^{-2} \cdot \boldsymbol{I} + 0.49$$

Monthly estimates of potential evapotranspiration calculated with this equation need to be adjusted for day length because 30 day months and 12 hour days were assumed when this relationship was developed. The adjusted potential evaporation accounting for month length and daylight duration is given by $\boldsymbol{ET_o} = 16 \cdot \left(\frac{10 \cdot \boldsymbol{t}}{\boldsymbol{I}} \right)^{\boldsymbol{a}} \cdot \frac{\boldsymbol{d}}{30} \cdot \frac{\boldsymbol{h}}{12}$, where ***d*** is length of the month in days, and ***h*** is the duration of daylight in hours on the fifteenth day of the month. However, there is no direct, unique relationship between temperature and energy. This limits the generality of the following temperature methods. Local calibration of the methods may provide some measure of accuracy, particularly for averaging periods on a monthly or seasonal basis. Some modifications were made to the original formula. The modifications consist in the exponent ***a*** determination through calculation of the parameter $\boldsymbol{a}_0$, $\boldsymbol{a}_1$, $\boldsymbol{a}_2$, $\boldsymbol{a}_3$ from the follow equation: $\boldsymbol{a} = \boldsymbol{a}_3 \cdot \boldsymbol{I}^3 - \boldsymbol{a}_2 \cdot \boldsymbol{I}^2 + \boldsymbol{a}_1 \cdot \boldsymbol{I} + \boldsymbol{a}_0$. This parameter values were calculated using a Maple software program written in Java language. The calibration was made for the Constanta station using the temperature and evapotranspiration values measured in the 1973-1995 period.

Monthly evapotranspiration (ETo) estimates for 10 locations in Dobrudja region are calculated by the modification Thornthwaite methods. The analysis of 40 years of data during the period of 1965–2005, was used for estimation of reference ET (ET_0) in Dobrogea region. The data (temperature and the evaporation measured) we used were obtained from the archives of the Romanian Institute National of Meteorology. Name of stations, locations, elevation and multi annual mean temperature are presented in Fig. 2



Location	Latitude	Longitude	Elevation (m)	1965 - 2005 Avg temp (^{0}C)
Sulina	$45^0 09'$	$29^0 39'$	2.08	11.49
Tulcea	$45^0 11'$	$28^0 49'$	4.36	11.14
Mangalia	$43^0 49'$	$28^0 35'$	6.00	11.57
Constanta	$44^0 13'$	$28^0 38'$	12.80	11.74
Harsova	$44^0 41'$	$27^0 57'$	37.51	11.00
Jurilovca	$44^0 46'$	$28^0 53'$	37.65	11.01
Medgidia	$44^0 15'$	$28^0 16'$	69.54	11.04
Cernavoda	$44^0 21'$	$28^0 03'$	87.17	11.15
Adamclisi	$44^0 08'$	$28^0 00'$	158.00	10.86
Corugea	$44^0 44'$	$28^0 20'$	219.20	9.94

Fig.2 – Locate of climate station

RESULTS AND DISCUSSIONS

Climatic data

The variation of the annual mean temperature for each station (Fig. 3) reveals the succession of the cold and warm year over the study period. It can be remarked that at all the stations the same evolution is preserved, i.e. starting to 1997, the mean annual temperature is higher than the multi - annual mean temperature at each station.

The multi-annual mean temperatures vary in small limits (10-12^{0}C approximately), the highest values being registered on the coast. The temperature values decrease with the altitude. The smallest temperature was registered at Corugea – on the centre (9.94^{0}C at 219.2m), and the biggest at Constantza (11.740C at 12.8m) and Mangalia (11.57^{0}C at 6.0m) – on the coast, Tulcea and Sulina at Danube Delta, respectively at Cernavoda (11.15^{0}C at 87.17m), on the Danube part.

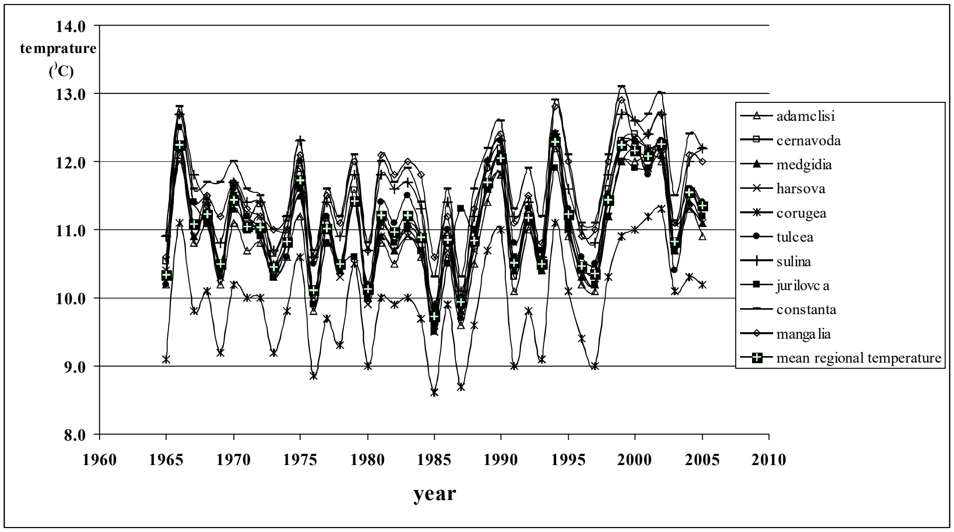


Fig.3 – The mean multi-annual temperature (period 1965-2005)

Evapotranspiration measured and calculated

The same behaviour is observed in the evapotranspiration measured evolution (Fig. 5). The annual mean evapotranspiration measured at Constanta station varies in the interval 691.4mm (in 1980) and 1028 mm (in 1990). In the period 1976-1988, the annual mean evapotranspiration is smallest than the multi-annual mean value (859.4mm). Starting to 1988, the annual mean evapotranspiration is higher than multi-annual mean value.

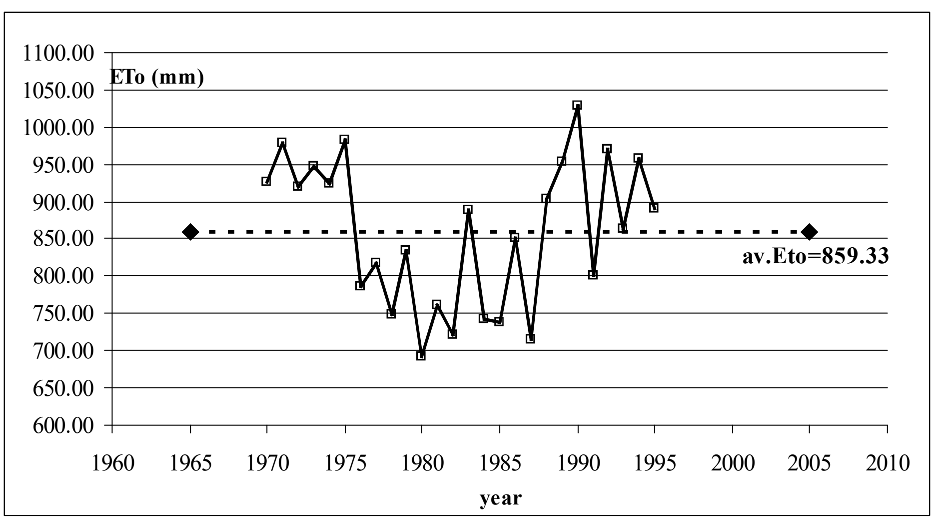


Fig.4 – The temporal evolution of the annual mean evapotranspiration measured

The parameters a_0, a_1, a_2, a_3 determinate by the program are:

a_o -58.62700 a_1 3.368792 a_2 -0.06331 a_3 0.000399

We note the original Thornthwaite equation with Eto-TO and the modified Thornthwaite equation with Eto-TM.

The results obtained for the Constanta station utilising ETo-TM relieve a good approximation of the evapotranspiration for the summer (June-August) period comparatively to the results obtained with ETo-TO (fig. 5); for the winter period we can not concluded because in this period doesn't exist the values of the evapotranspiration measured.

In the period march-may and September-November, the evapotranspiration is underestimated.

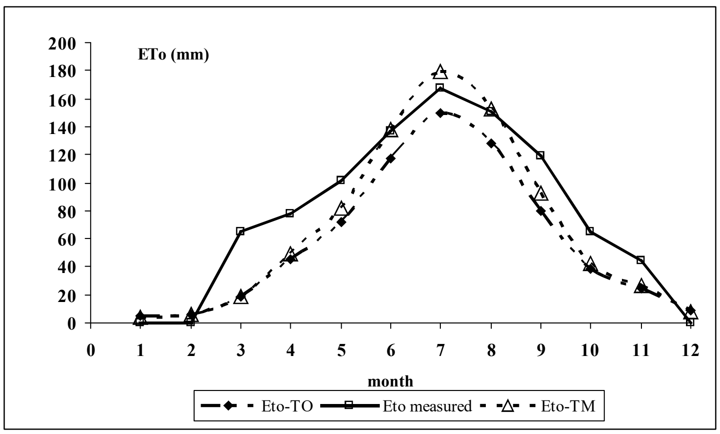


Fig.5 – Example

Table 1

Descriptive Statistics of the multi annual evapotranspiration distribution at 10 climate stations (units mm)

Station	Multi-annual mean	Maximum	Minimum	Cv
Adamclisi	700.4	861.8	378.5	0.154
Cernavoda	696.6	903.6	637.5	0.263
Medgida	718.4	861.8	455.3	0.140
Harsova	755.3	882.5	517.7	0.116
Corugea	519.8	813.3	161.8	0.358
Tulcea	760.1	889.9	560.7	0.106
Sulina	776.0	956.9	614.3	0.101
Jurilovca	726.6	890.4	418.6	0.149
Constanta	797.9	1013.7	642.6	0.097
Mangalia	753.6	890.5	532.7	0.118

Applying the ETo-TM formula for the all weather station, we note that the losses by evaporation (multi-annual mean) varies between 519.8mm at Corugea station and 797mm at Constanta station, the highest values being registered on the coast (Mangalia– 890.5mm, Sulina – 957mm, Tulcea- 889.9mm, Constanta – 1013.7mm).

Table 1 present the descriptive statistics of the multi - annual mean evapotranspiration at the wheatear stations. Since the coefficient of variation (Cv) are very small, it results that there is a very small dispersion of the multi – annual mean evapotranspiration in space.

CONCLUSIONS

In order to improve the Thornthwaite method performance the 26-years evaporation data derived from Constanta station was used for fitted the Thornthwaite formula. The parameter $\boldsymbol{a}_0$, $\boldsymbol{a}_1$, $\boldsymbol{a}_2$, $\boldsymbol{a}_3$ values were calculated using a Maple software program. Evapotranspiration monthly values for Constanta station were calculated using Thornthwaite original formula and Thornthwaite modified formula for the 1970-1995 periods. The Thornthwaite modified method appears to provide comparatively reasonable values during the summer for Constanta station, but underestimates ETo during the remainder of the year. The regional analysis of the evapotranspiration for the period 1965-2005 from 10 meteorological station prove that the smallest losses by evaporation was registered at Corugea, and the biggest on the coast, respectively on the Danube part, so the evapotranspiration decrease from the coast to interior and from the Danube (seat on the West side of the region) to the interior.

REFERENCES

1. **AlKaeed O., Flores C., Jinno K., Tsutsumi A., 2006 –** *Comparison of several evapotranspiration method for Itoshima Peninsula Area, Fukoka, Japan*. Momoirs of the Faculty of Engineering, Ksyuhu University, Vol. 66, No. 1.

2. **Maftei C. 2002 -** *Etudes concernant les écoulements superficiels*. Thèse de doctorat; Université de Montpellier France et Université „Ovidius" Constanta, Roumanie.

3. **Thornthwaite C. W. 1948** - *An approach toward a rational classification of climate.* Geography. Rev. 38 (1), 55-94.

4. **Thornthwaite C. W. and Mather, J.R., 1955 -** *The water balance. P*ubl. Climatolog. Lab. Climatolog. Dresel Inst. Technol., 8 (1), 1-104.

5. **Sharma M.L., 1985 -** *Estimating evapotranspiration*. *Advances in irrigation*. D. Hillel, ed., Academic, London, 213-281.

GIS USED IN RECENT ANTHROPIC RELIEF ALTERATIONS ASSESSMENT WITHIN CĂLIMANI NATIONAL PARK

GIS UTILIZAT ÎN EVALUAREA MODIFICĂRILOR ANTROPICE RECENTE ASUPRA RELIEFULUI ÎN PERIMETRUL PARCULUI NAȚIONAL CĂLIMANI

CONDORACHI D.
"Al. I. Cuza" University of Iaşi

Abstract. *Interesting mineral resources economic areas were always intensely humanized and are displaying, sometimes, dramatic changes of the landscape, especially on topography. The communist period, with centralized economy, the state desire to be independent energetically and resource pools at any costs often generated, huge transforming works on landscape, but with doubtful economic results. The impact on the original topography is devastating, with pollution phenomena in the environment, which bluntly modifies the rhythm, direction and the intensity of the relief normal evolution. A characteristic example is the large sulphur open quarry in the Călimani Mountains, now engulfed in the National Park with the same name. Are presented selected morphometrical and morphographical indices which are relevant to describe the actual status in two distinct moments before opening the mining works and after closing the exploitation. This kind of analysis is relevant and useful to scientific founding for all the actions that may be taken for ecological rehabilitation of this former mining area..*

Rezumat. *Arealele interesante din punctul de vedere al resurselor minerale au fost întotdeauna intens antropizate, prezentând , uneori, modificări radicale ale peisajului, în special ale reliefului. Perioada comunistă, cu economie centralizată, dorința statului de a deveni cu orice preț independent din punct de vedere energetic şi al rezervelor de resurse minerale a generat, deseori, lucrări transformante de mare amploare asupra reliefului, dar cu rezultate economice îndoielnice. Impactul asupra reliefului original este devastator, cu declanşarea unor procese geomorfologice intense, de fenomene de poluare asupra mediului, care modifică radical ritmul, sensul şi intensitatea sensului de evoluție a reliefului. Un exemplu relevant îl constituie imensa carieră de exploatare a sulfului din Masivul Călimani, acum inclusă în perimetrul Parcului Național Călimani. Sunt prezentate câteva aspecte morfometrice şi morfografice relevante în două situații distincte, înainte de deschiderea carierei şi după închiderea exploatării. Analiza este interesantă şi utilă pentru fundamentarea demersurilor care se fac pentru reabilitarea ecologică a acestui areal minier.*

GIS and RS can successfully be used for assessing anthropic impact on topography. Precision and the wealth of quantitative data can be used for many purposes and in this example may be useful for site ecological rehabilitation.