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Evapotranspiration in The Tatra Mountains In Central Europe

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ABSTRACT Evapotranspiration in the mountains represents an important water balance element. Unfortunately, our knowledge and possibilities for its direct determination are only limited. Results of the analysis of both potential and actual evapotranspiration in Central European Tatra Mountains are presented. The calculations are based on complex method. Totally 10 stations in elevation range from 115 m a.s.l. to 2635 m a.s.l. in 1956-1980 period were used. The role of evapotranspiration in the water balance is described by means of comparison with precipitation amounts.

Tatra Mountains are the highest mountains in Czechoslovakia with elevations up to 2655 m a.s.l. at Gerlachovsky Peak. They are located on the borders with Poland. They form a part of larger system of the Carpathians covering most of the territory of Slovakia. They are relatively young mountains originated at the same period as the Alps and consist mostly of granites. From the water management point of view they are important as the headwaters of many streams in Slovakia, among them of Vah river, the largest river basin in Slovakia. The higher parts of the mountains represent a region with cold moist climate with mean yearly temperatures below zero, eight months covered with snow and precipitation depths up to 2,000 mm per year.

The knowledge of evapotranspiration is fundamental for different water projects and due to mountainous character of the territory is difficult to determine. Nine meteorological stations on the territory of about 1,500 km sq. were selected in the region for calculation of the evapotranspiration. They are situated in different elevations from 576 m a.s.l. in the main valley up to 2,635 m a.s.l. on the mountain range. For comparison a typical lowland station (115 m a.s.l.) was added. The calculations were carried on for 25 years period 1956 - 1980. The overview of the stations is in Table 1.

The complex method for determination of both potential and actual evapotranspiration was originated by Budyko (1961). It is based on common solution of the water balance and heat budget. The energetical income on the evaporating surface is described by the heat budget equation

$$R_N = L\ ET + H_S + A \qquad (1)$$

and the moisture content by the water balance equation

$$P = ET + R + (W_2 - W_1), \qquad (2)$$

where R_N is net radiation, L latent heat of vaporatization, ET evapotranspiration, H_S sensible heat exchange with atmosphere, A heat flowing to the ground, P precipitation, R surface runoff, W_1 and W_2 are soil moisture changes during the period concerned.

The potential evapotranspiration is transformed to actual by equation

$$ET = PET \frac{W_M}{W_O}, \qquad (3)$$

where PET is potential evapoteranspiration, W_M mean soil moisture for the period and W_O is the critical soil moisture.

The details on the individual elements of the equations (1) to (3) can be found in many textbooks and other papers (e.g. Budyko, 1961, Tomlain, 1990) and can't be fully described here. The results of the calculations are summarized in Table 1.

Results of the calculations confirmed the expected decrease of evapotranspiration with increasing elevations of the stations. The results of the calculations are plotted in Figure 1. The potential evapotranspiration shows an exponential decrease of the values with elevation. This basic tendency is being disturbed in three stations in 972, 1330 and 1778 m a.s.l. These three stations are situated on the southern slopes of the Tatra Mountains with favourite climatic conditions what enables higher income of radiant energy and better conditions for evaporation.

Evapotranspiration plays an important role in water balance of the region. This importance can be demonstrated by the coefficient of evapotranspiration (Tomlain, 1990), which represents a ratio of evapotranspiration to the precipitation, expressed in percentage.

The evapotranspiration coefficient presented in Table shows that in the lowlands the actual evapotranspiration represents up to 80 % of the precipitation, in main valleys it is about 70 %, in middle slopes varies between 60 and 40 % and on the tops decreases to 20 % of the precipitation. From that follows that for the Tatra watersheds the evapotranspiration forms about one third of the water balance and as a quite important factor must be taken into consideration in different water management studies in the region.

Table 1: Mean potential (PET) and actual (ET) evapotranspiration, elevations and ratio to precipitation (P) 1956 - 1980

station	elevation m a.s.l.	PET mm/year	ET mm/year	ET/P %
Hurbanovo	115	859	431	79
Lipt.Mikulas	576	662	482	70
Lipt.Hradok	643	622	466	69
Poprad	703	632	444	74
Tatr.Lomnica	850	565	473	59
Podbanske	972	588	492	53
Strbske Lake	1330	563	475	49
Skalnate Lake	1778	496	466	36
Chopok Peak	2004	337	319	28
Lomnicky Peak	2635	297	288	22

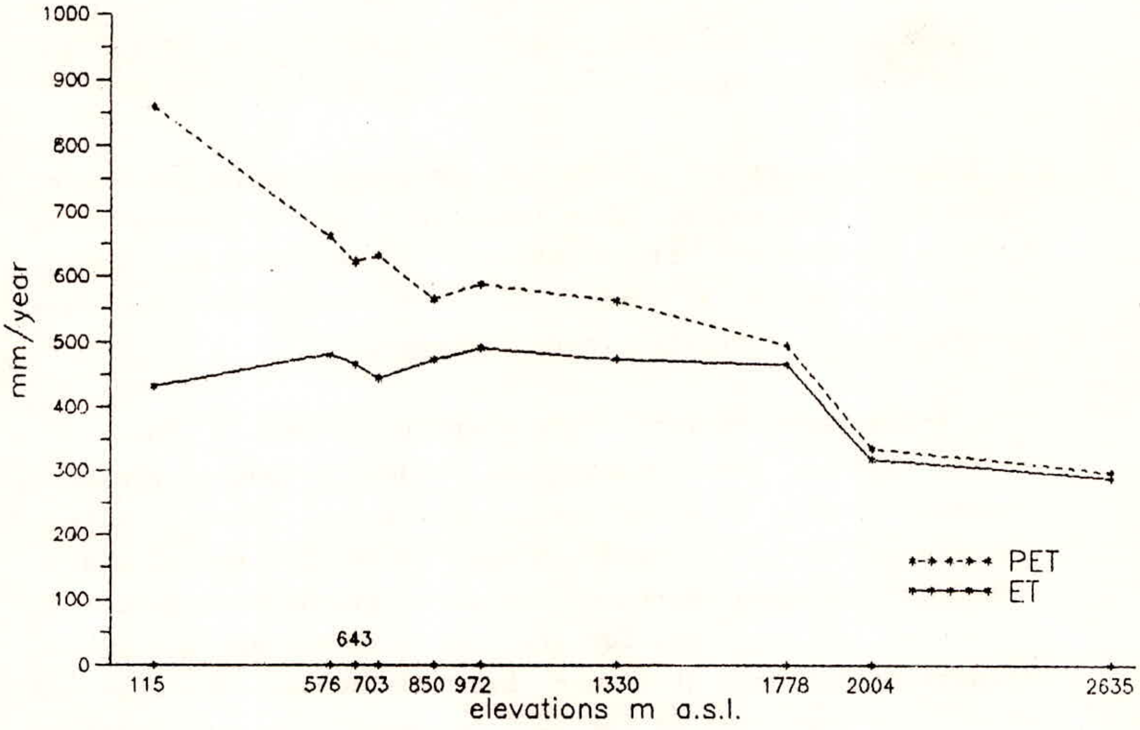

Figure 1 : The decrease of potential (PET) and actual (ET) evapotranspiration with elevations in the area.

REFERENCES

Budyko, M. I., 1961 : The determination of evaporation from the surface of the Earth. (In Russian.) Izdatelstvo AN SSSR, ser. geography, No.6.

Molnar, L., Meszaros, I., 1990 : Experimental study of transpiration in mountainous research basin. TNO Proc. and Inf. No. 44, The Hague, Netherlands, pp. 71-79.

Molnar, L., Miklanek, P., 1989 : Problems of the water balance components determination in a mountainous watershed. Proc. Int.Workshop on Hydr. of Mountainous Areas, Strbske Pleso. IAHS Publ. 190, Wallingford, UK, pp. 167-178.

Tomlain, J., 1990 : The distribution of the evapotranspiration coefficient on the territory of Slovak Republic. (In German.) Acta Meteorol. Univ. Comenianae, XIX, Bratislava.