CHARACTERIZATION OF GROUND WATER REGIME

by

J. WINTER

Institute of Water Management and Hydraulic Engineering, Technical University, Budapest

(Received February 8, 1972)

Presented by Prof. I. V. NAGY

Our research program aimed essentially at forecasting the ground water regime. The presented analyses — applying a digital computer — approached this aim methodologically and practically.

1. Probability characterization

1.1. Fitting tests

Some thirty ground-water gaugings in the Great Hungarian Plain with a data row of at least 25 years and of a water course indisturbed or nearly have been studied. The indisturbance has been verified by homogeneity tests. Data rows being not independent of each other and in themselves, empiric distribution functions have been approximated by *fitting distribution functions.*

Data rows of both yearly typical water levels (minimum, mean, maximum) and of monthly values can closely be approximated by *Normal* distribution functions. Fitting probability is about 60 to 70%, much beyond the usual significance level of 5%.

1.2. Parameter variation

Among parameters of the Normal distribution function, the mean value $\bar{x}$ performs a period during one year — in conformity with the yearly periodicity of the ground water regime. Again, the deviation σ has a yearly period. Variation of both parameters can be described by the equation:

$$y_t = A_0 + A_1 \sin\left(\frac{\pi}{12} t - B_1 \frac{12}{\pi}\right) + A_2 \sin\left(\frac{2\pi}{12} t - B_2 \frac{12}{2\pi}\right) + \dots$$

taking term 1 into consideration being sufficient for describing the mean value, and terms 1 and 2 for describing the deviation. This means that the yearly period of σ is disturbed by a weak half-year period. Often the amplitude of the period is so small that the deviation may be considered as constant around the year.

Peak of the mean value occurs in the months from April to June — depending on the ground water depth and on the soil conditions — preceded by the deviation peak one or two months before (Fig. 1).

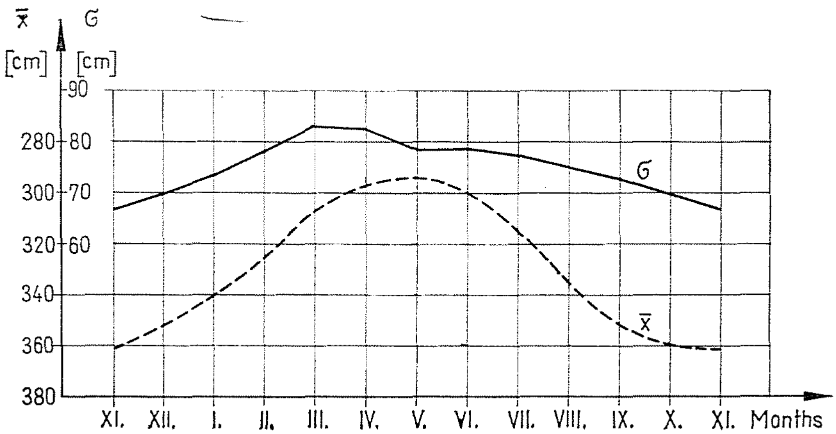

Fig. 1. Average from 17 gaugings

Mean value and deviation for a given month are in an elliptic relationship. Shifting the deviation by one or two months results in a linear relationship (Fig. 2).

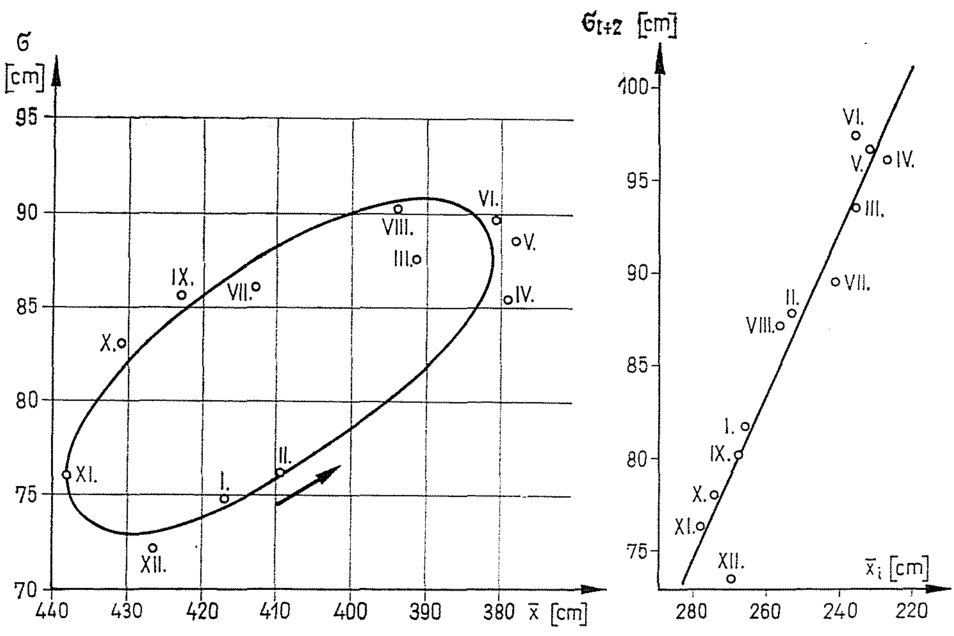

Fig. 2 Correlation between parameters, gauge 360

2. Relationships of ground water time sequences

To prepare the forecast, factors primarily affecting the ground water have been investigated.

2.1. Interrelations between ground water time sequences

The important inertia of the ground water system inhibits any great deviation between consecutive months. The numerical description of this relation is done by autocorrelation analysis (assuming linear regression):

$$r(K) = \frac{\sum_{i=1}^{N-K} (X_i - \overline{X}_i)(X_{i+K} - \overline{X_{i+K}})}{\sigma_i \sigma_{i+K} (N-K-1)} \,.$$

Fig. 3 shows the autocorrelation function not to decrease below 0.5 even at the 12th interval (one year). Thus, a forecast for several months may ad

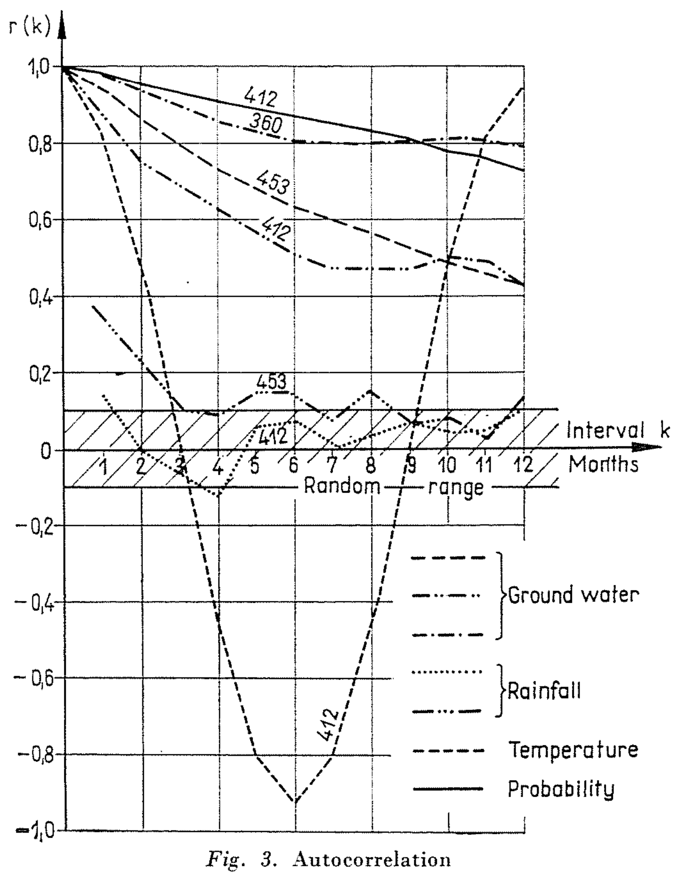

Fig. 3. Autocorrelation

visably start from some previous ground water. Ground water probabilities within the proper basic periods are already closer related (Fig. 3). This fact must absolutely be taken into consideration in forecasting.

2.2. *Effect of rainfall and temperature*

The evolution of ground water is primarily a function of rainfall and temperature (via evaporation). To take the effect of both factors into consideration, cross-correlation functions of ground water vs. rainfall and of ground water vs. temperature have been established (Fig. 4).

Cross-correlation coefficients but slightly exceed the random limit (95% significance level).

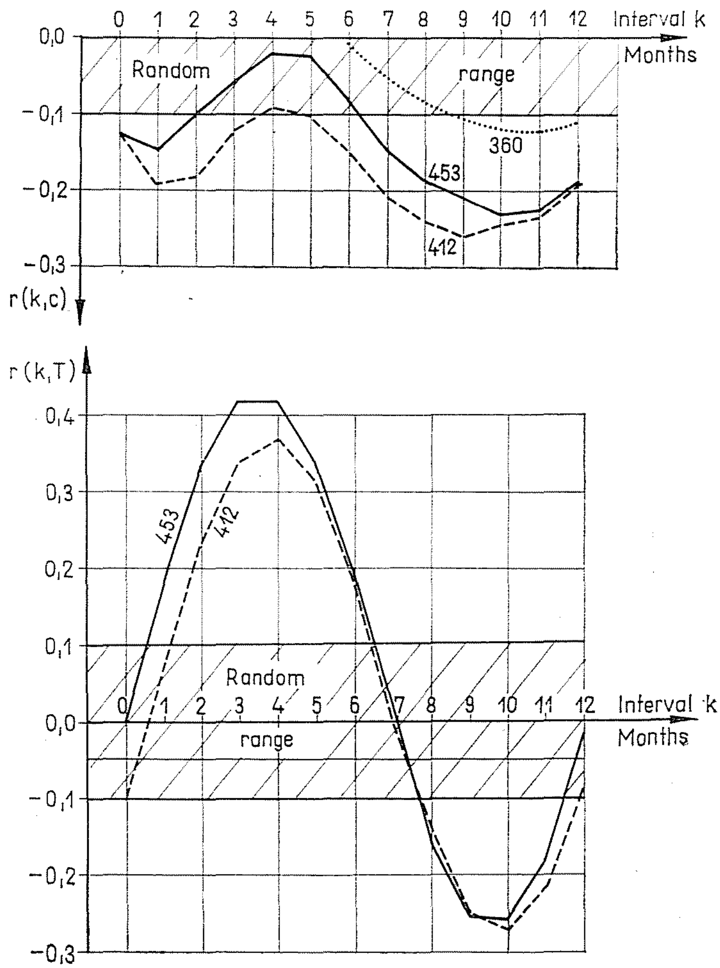

Fig. 4. Ground water to rainfall and ground water to temperature cross-correlations

For rainfall, the correlation function is at its maximum in intervals 9 to 11. A moderate maximum occurs even at interval 1, promising for a 1 to 3-month forecast. Because of the low values of correlation coefficients, it may be advisable to take total rainfalls from several (two or three) subsequent months into consideration.

Cross-correlation coefficients vs. temperature are higher than the former and also the amplitude of the yearly period is greater (Fig. 4), attributed to the yearly periodicity of temperature, much more intensive than that of rainfall. From the figure it appears that the greatest likelihood of a forecast starting from temperature is that for months 2 to 5 and 9 to 10.

3. Effect of rainfall and temperature for each basic period

The above cross-correlation analysis has also been done for monthly intervals. Thereby the number of data decreased by 12 times, and though, more of the correlation coefficients proved to be stable.

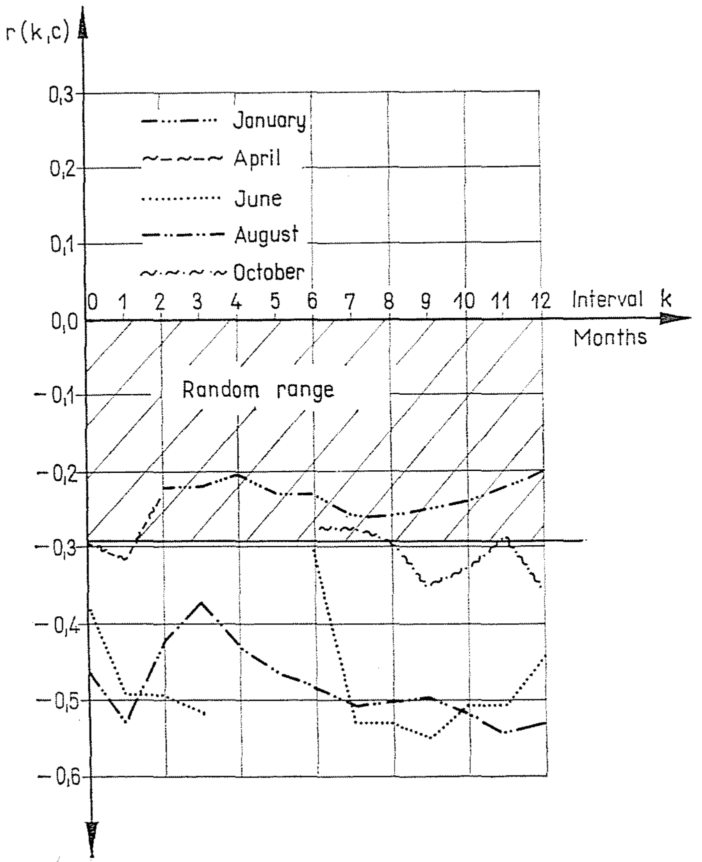

Fig. 5. Rainfall to ground water cross-correlation

3.1. *Effect of rainfall*

Stable correlation coefficients ordered according to rainfalls are plotted in Fig. 5. It is clearly seen that but a few months have correlation coefficients outside the random range, namely the same months for the tested six gaugings, while other months are invariably missing. Hence, for the evolution of the ground water for any month of the year, rainfalls in certain months (January, June, October) prevail over the others.

Besides of these months, others may be of importance — even if slighter — for some gauging (more for those with higher ground water regime).

3.2. *Effect of temperature*

By analogy with rainfall, effect of temperature on ground water of consecutive months has been investigated. Our findings and conclusions are similar to the former.

Fig. 6 shows cross-correlation coefficients of but a few months to lay

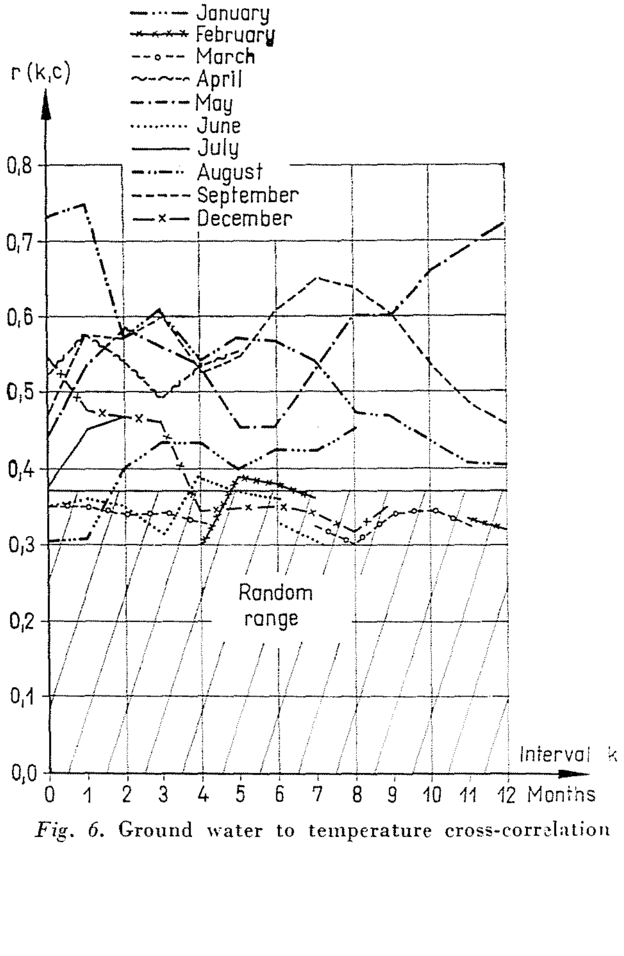

Fig. 6. Ground water to temperature cross-correlation

regularly outside the random range. This points to the prevalence of a few months' temperature for the water table evolution in any month of the year, others being practically irrelevant.

As concerns temperature, the greatest effect is due to January, May and August, and for some wells, to the adjacent months (December, September).

Summary

Investigations have led to the conclusion that ground water forecasts should be based on probabilities (according to Normal distribution functions), rainfall and temperature in some designated months previous to the tested one, eventually on interrelations between and yearly periodicity of distribution function parameters.

Senior Ass. János WINTER, 1111 Budapest, Műegyetem rkp 3. Hungary