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Numerical representation of rainfall field in the Yarmouk River Basin

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Rainfall is the decisive factors in evaluating the water balance of river basins and aquifers. Accepted methods rely on interpolation and extrapolation of gauged rain to regular grid with high dependence on the density and regularity of network, considering the relief complexity. We propose an alternative method that makes up to those restrictions by taking into account additional physical features of the rain field. The method applies to areas with (i) complex plain- and mountainous topography, which means inhomogeneity of the rainfall field and (ii) non-uniform distribution of a rain gauge network with partial lack of observations. The rain model is implemented in two steps:
1. Study of the rainfall field, based on the climatic data (mean annual precipitation), its description by the function of elevation and other factors, and estimation of model parameters (normalized coefficients of the Taylor series);
2. Estimation of rainfall in each historical year using the available data (less complete and irregular versus climatic data) as well as the a-priori known parameters (by the basic hypothesis on inter-annual stability of the model parameters).

The proposed method was developed by Shentsis (1990) for hydrological forecasting in Central Asia and was later adapted to the Lake Kinneret Basin. Here this model (the first step) is applied to the Yarmouk River Basin.

The Yarmouk River is the largest tributary of the Jordan River. Its transboundary basin (6,833 sq. km) extends over Syria (5,257 sq.km), Jordan (1,379 sq. km) and Israel (197 sq. km). Altitude varies from 1800 m (and more) to -235 m asl. The total number of rain stations in use is 36 (17 in Syria, 19 in Jordan). There is evidently lack and non-uniform distribution of a rain gauge network in Syria. The Yarmouk Basin was divided into five regions considering typical relationship between mean annual rain and elevation for each region. Generally, the borders of regions correspond to the common topographic, geomorphologic and climatic division of the basin. Difference between regional curves is comparable with amplitude of rainfall variance within the regions. In general, rainfall increases with altitude and decreases from west to east (south-east).

It should be emphasized that (i) Lake Kinneret Basin (2,490 sq. km) was earlier divided into seven "orographic regions" and (ii) the Lake Kinneret Basin and the Yarmouk River Basin are presented by the system of regional curves X = f (Z) as one whole rainfall field in the Upper Jordan River Basin, where the mean annual rain (X) increases with altitude (Z) and decreases from west to east and from north to south. In the Yarmouk Basin there is much less rainfall (344 mm) than in the Lake Kinneret Basin (749 mm), wherein mean annual rain (2,352 MCM versus 1,865 MCM) is shared between Syria, Jordan and Israel as 80%, 15% and 5%, respectively.

The provided rainfall data allow more precise estimations of surface water balances and of recharge to the regional aquifers in the Upper Jordan River Basin. The derived rates serve as fundamental input data for numerical modeling of groundwater flow. This method can be applied to other areas at different temporal and spatial scales. The general applicability makes it a very useful tool in several hydrological problems connected with assessment, management and policy-making of water resources, as well as their changes due to climate and anthropogenic factors.

Reference:
I. Shentsis (1990). Mathematical models for long-term prediction of mountainous river runoff: methods, information and results, Hydrological Sciences Journal, 35:5, 487-500, DOI: 10.1080/02626669009492453