Optimum Number of Rain-Gauges Using Factor Analysis

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Abstract

Any hydrological investigation requires enough information about precipitation. Sufficient and reliable rainfall information requires rain-gauges with proper location and number. Designing a network with optimum number of rain-gauges may help to achieve required information with needed accuracy and minimum cost. Factor Analysis, as a multivariate analysis tool, combined with traditional network design method is employed to find optimum number of rain-gauge network in this study. This method is applied on precipitation data collected from Kohkiloye and Boyerahmad, province in South Western of Iran. The results show that good advantages of factor analysis can be combined with inappropriate features of tranditional method to come up with an efficient and optimum number of stations in a region.

Keywords: Network design, Factor Analysis, Variogram, Rain-gauge network

1. INTRODUCTION

Data acquisition is the most fundamental stage in any hydrologic analysis. Information associated wit rainfall as motivator and the driving force for all processes within the hydrologic cycle seems to be a basic tool to be acquainted with even other rings of the chain. Collecting data for highly stochastic phenomena in a terrestrial region requires a network. The observation network design involves the following inter-related factors: (1) observation effort (cost, time, instrumentation, etc.); (2) relative importance of the various parameters; (3) the different geostatistical properties of the parameters and (4) estimation accuracy or error criteria for the various parameters.

The problem of rainfall data collection network design has been categorized into three classes [1]. First and second classes relate to problems as regional estimation; i.e., there is no clearly defined final goal or use for the collected data. Third class networks are those designed to collect data for specific clearly defined objective which implies known net benefits and utility of data. Problems of designing a network to obtain the areal mean rainfall are related to the first class.

The optimum rain-gauge network design constitutes the least number of rain-gauges that must be operated in order to obtain optimum rainfall information for the certain water use activities declared above, over a desired region. The optimization are generally known as the variance reduction method [e.g., 2, 3, 4, 5, 6 and 7], which involves searching for an appropriate number of rainfall gauges and their locations. These approaches require an optimization strategy to minimize number of stages for adequate variance. For example, Pardo-Iguzquiza [8] applies simulated annealing as an algorithm of random search for optimal location of measurement gauges, taking into account the double criterion of estimation accuracy and economic cost.

Variance reduction requires testing multiple combinations of stages to discover an acceptable number of them. This would certainly entail lengthy CPU time for analysis even with modern computers.

In this study, Factor Analysis (FA) is used as an indirect tool to investigate the optimum number of rain-gauges and expedite the delineation process compared to traditional network design. The primary purpose in FA is to define the underlying structure in a data set. Broadly speaking, it addresses the problem of analyzing the structure of correlations among a large number of variables. By defining a set of common underlying dimensions known as *factors*, with FA, one can first identify the separate dimensions of the structure and then determine the extent to which each variable is explained by each dimension. Once these dimensions and the explanation of each variable are determined, the two primary uses for FA, summarization and data reduction, can be achieved. The model then applied to rainfall data from the mountainous region of Kohkiloyeh and Bouyerahmad province. A comparative analysis is also conducted on the data.