Comparison of different geostatistical methods to estimate groundwater level at different climatic periods

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Abstract
The main aim of this study has been to assess the spatial variability of groundwater level at different climatic periods. The study area is Saveh-Nobaran aquifer in Iran. First, using two drought indices, different climatic periods in the region including wet, normal and dry during 1993–2003 were recognized. Second, with the use of measured elevations of the water table, experimental semivariograms (spherical, exponential and Gaussian) were constructed that characterize the spatial variability of the measured groundwater levels. Groundwater levels were interpolated by four different geostatistical methods. RMSE, MAE and $R^2$ were calculated to determine the best method. The $R^2$ coefficient obtained from kriging, cokriging, TPSS and IDW methods were 0.95, 0.97, 0.89 and 0.83, respectively. Cokriging method was used to create groundwater-level maps, including maximum, average and minimum water levels for each climatic period. The results obtained from geostatistical analysis showed that groundwater depth varies spatially in different climatic conditions.

Introduction

Groundwater is a major source of supply for domestic and agricultural purposes, especially in arid and semiarid regions (Nayak et al. 2006; Ta-Any et al. 2009). Management of this resource is very important to meet the increasing demand of water for domestic, agricultural and industrial use. Various management measures are needed to know the spatial and temporal behaviour of groundwater. Observed groundwater levels serve as one of the main input data in studies related to groundwater simulation for various purposes as required in water balance studies, estimation of groundwater recharge potential, in the design of drainage structures, and so on (Kumar & Remadevi 2006).

Iran is located in an arid to semi-arid region of the world, and about 95% of fresh water is allocated for agriculture, out of which 80% is supplied through groundwater. Therefore, it is clearly concluded that groundwater is the vital component for sustainable agriculture. In recent years, many fertile and agricultural plains suffered from 0.5 to 15 m water table-level drop, in which many wells are now out of use (Ahmadi & Sedghamiz 2007). Understanding the behaviour of groundwater body and its long-term trends are essential for making any management decision in a given watershed (Reghunath et al. 2005). Therefore, having a deep knowledge and insight on the groundwater system seems necessary for optimum exploitation of the water.

Among the several proposed drought-monitoring indices, the standardized precipitation index (SPI) has found widespread application for describing and comparing droughts among different time periods and regions with different climatic conditions. (Cancelliere et al. 2007).

For the first time, McKee et al. (1993) specified the SPI for verifying the probability of drought’s expansion. This symbol has been designed for lacking the rainfall in different periods, and it represents the drought’s effects in various terms over the amount of water resources. McKe et al. (1995) took this matter into consideration and put the SPI under study in 3-, 6-, 12-, 24- and 48-month periods.

The SPI has been used extensively for drought analysis at country and continental level in the United States (Hayes et al. 1999; Keyantash & Dracup 2002), United Kingdom (Lloyd-Hughes and Saunders 2002), South Africa (Rouault & Richard 2003), Hungary (Domonkos 2003), Italy (Bonaccorso et al. 2003; Bordi et al. 2006), Korea (Min et al. 2003) and Greece (Tsakiris & Vangelis 2004).

The standard index of annual precipitation (SIAP) has been suggested as the best index for assessing drought in Iran.