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ORIGINAL ARTICLE

Comparison of deterministic and stochastic methods to predict spatial variation of groundwater depth

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Abstract Accurate and reliable interpolation of groundwater depth over a region is a pre-requisite for efficient planning and management of water resources. The performance of two deterministic, such as inverse distance weighting (IDW) and radial basis function (RBF) and two stochastic, i.e., ordinary kriging (OK) and universal kriging (UK) interpolation methods was compared to predict spatio-temporal variation of groundwater depth. Pre- and post-monsoon groundwater level data for the year 2006 from 110 different locations over Delhi were used. Analyses revealed that OK and UK methods outperformed the IDW method, and UK performed better than OK. RBF also performed better than IDW and OK. IDW and RBF methods slightly underestimated and both the kriging methods slightly overestimated the prediction of water table depth. OK, RBF and UK yielded 27.52, 27.66 and 51.11 % lower RMSE, 27.49, 35.34 and 51.28 % lower MRE, and 14.21, 16.12 and 21.36 % higher R^2 over IDW. The isodepth-area curves indicated the possibility of exploitation of groundwater up to a depth of 20 m.

Keywords Delhi · Groundwater depth · Inverse distance weighting · Ordinary kriging · Radial basis function · Universal kriging

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Introduction

Scientific management of groundwater resources is important for its sustainable development. So, there is a need of adequate information about spatio-temporal behavior of water table depths over a region. Water table depth measurements, however, are inherently expensive and time consuming, particularly during the installation phase, which requires drilling a well or a piezometer. Consequently, the number of water table depth measurements that are available in a given area is often relatively sparse and does not reflect the actual level of variation that may be present. Therefore, accurate interpolation of water table depth at unsampled locations is needed for better planning and management.

For mapping of water table depth, the approach of interpolation has either been deterministic, such as inverse distance weighting (IDW) (Gambolati and Volpi 1979; Buchanan and Triantafilis 2009; Sun et al. 2009; Varouchakis and Hristopulos 2013; Arslan 2014) and radial basis function (RBF) (Sun et al. 2009; Arslan 2014) or stochastic, such as ordinary kriging (OK) (Desbarats et al. 2002; Kumar and Ramadevi 2006; Ahmadi and Sedghamiz 2008; Sun et al. 2009; Varouchakis and Hristopulos 2013; Arslan 2014) and universal kriging (UK) (Reed et al. 2000; Kumar and Ahmed 2003; Kumar 2007; Sun et al. 2009, Varouchakis and Hristopulos 2013).

Deterministic interpolation techniques create surfaces from sample points using mathematical functions, based on either the extent of similarity (IDW) or the degree of smoothing (RBF). On the other hand, geostatistical interpolation techniques (kriging) utilize the statistical properties of the sample points. It quantifies the spatial autocorrelation among sampling points and accounts for the spatial configuration of the sampling points around the prediction location (Buchanan and Triantafilis 2009).