Cokriging of the phreatic level using a digital elevation model, DEM

Mendoza, Edgar[1]; Herrera, Graciela[2] y Díaz, Martín[3]

[1]DEPFI, UNAM, Av. Cuauhnáhuac, número 8532, Colonia Progreso, Jiutepec, Morelos, México; Tel: (777) 3293600 Ext. 216, Fax: (777) 3293682; edgaryuri@hotmail.com

[2]Instituto Mexicano de Tecnología del Agua, Av. Cuauhnáhuac, número 8532, Colonia Progreso, Jiutepec, Morelos, México; Tel: (777) 3293600 Ext. 216, Fax: (777) 3293682; gherrera@tlaloc.imta.mx

[3]Instituto Mexicano del Petróleo, Eje Central Lázaro Cárdenas, 152, Col. San Bartolo Atepehuacan, Del. Gustavo A. Madero, C.P. 07730, México, D.F., Tel: (55) 91-75-8299, Ext. 6993, Fax: (55) 91-75-6993; mdiazv@imp.mx

INTRODUCTION

•Contour maps of phreatic level in aquifers are used to analyze the behavior of groundwater levels, and flow directions.
•Interpolation linear methods, like ordinary kriging (KO), have demonstrated their effectiveness.
•If little information exists, the estimation is smoothed.
•Hoeksema *et al*. (1989), showed that for geological settings where the phreatic level is a subdues replica of the ground surface, cokriging can be used to estimate the phreatic level elevation using ground surface elevation as a secondary variable.
• This principle is the basis for using secondary information from digital elevation models (DEM) to supplement sparse water well observations for mapping phreatic surfaces (Desbarts *et al*. 2002).

OBJECTIVE

•To apply cokriging using topographic information of DEMs, to estimate phreatic level elevations in two different aquifers.

THE PHREATIC LEVEL AND DEM DATA

•Primary data is water table elevations in meters above sea level in a set of wells.
•The gridded data for the secondary variable is derived from a 1:50,000 scale, 50 m resolution digital elevation model based on the NAD27 datum.

APPLICATION TO MEXICALI AQUIFER

•Water table elevation data is available at 90 wells in the valley.
•The aquifer is unconfined in steady-state conditions.

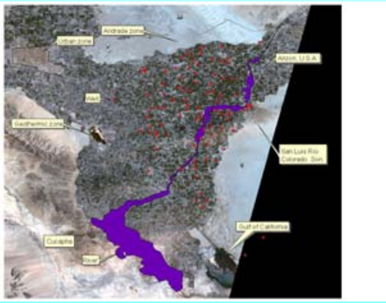

Figure 1. Mexicali valley and location of 90 wells with preatic level data.

SCATTERGRAM AND STATISTICAL DATA

•The linear relation between the primary and secondary variables was checked and a good correlation was obtained.
•The minimum and maximum water level elevation are 6.93 m and 22.76 m, respectively.
•In the variables analyzed a drift effect was observed and it was necessary to adjust a polynomial of second order to estimate it. The polynomial was substracted from the original data and the geoestatistical analysis was done with the residuals.

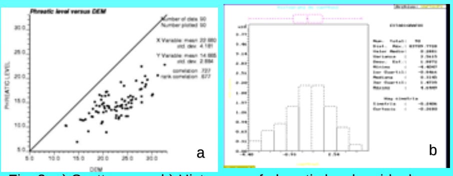

Fig. 2, a) Scattergram; b) Histogram of phreatic level residuals.

SEMIVARIOGRAMS

UNIVARIATE

•The residuals semivariogram of the phreatic level and of the DEM data were fitted with a spherical model.

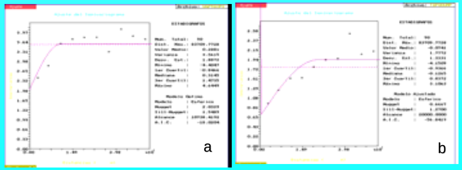

Figure 3, a) Phreatic level semivariogram; b) DEM semivariogram

BIVARIATE

•A spherical model was fitted to the cross semivariogram.

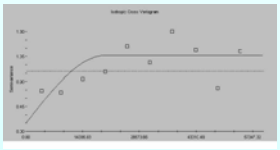

Fig. 4, Cross-semivariogram

ESTIMATION

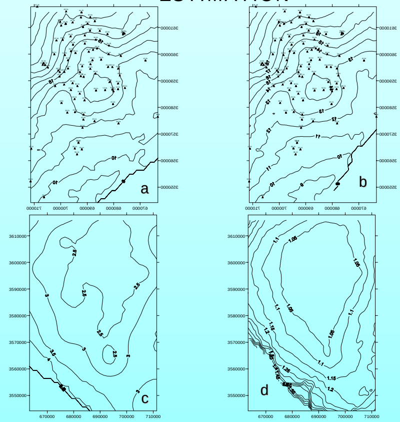

Fig. 5, a) OK; b) COK; c) COK variance; d) OK variance/ COK variance.

APPLICATION TO QUERETARO AQUIFER

•Unconfined aquifer with local confinements.
•The effects of withdrawal by pumping wells produced a cone of depression centered upon the City of Queretaro.
•The hypothesis that groundwater flow follows the topography is or
•C

Figure 6, Queretaro Valley and region in which cokriging was Applied.

STATISTICAL DATA

•Phreatic levels available at 85 wells.
•Minimum and maximum water level elevations: 1640.4 m and 1894.4 m.
•The correlation coefficient is 0.85.
•The drift effect was estimated using the same procedure as for the Mexicali aquifer.

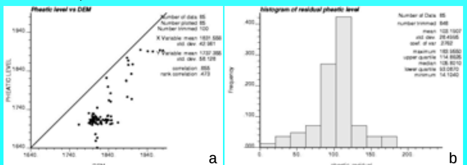

Figure 7, a) Scattergram; b) Histogram of phreatic level residuals.

SEMIVARIOGRAMS

UNIVARIATE

•The residuals semivariogram for the phreatic level and the DEM data were fitted with a spherical model.

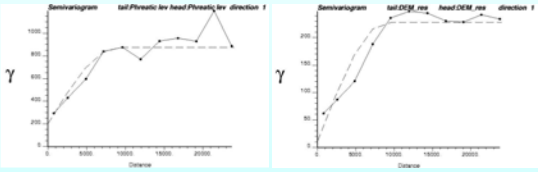

Fig. 8, a) Phreatic level semivariogram; b) DEM semivariogram

BIVARIATE

•A spherical model was fitted to the cross semivariogram.

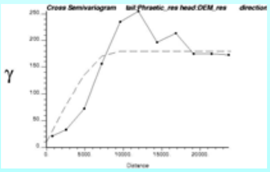

Fig. 9, Cross-semivariogram

ESTIMATION

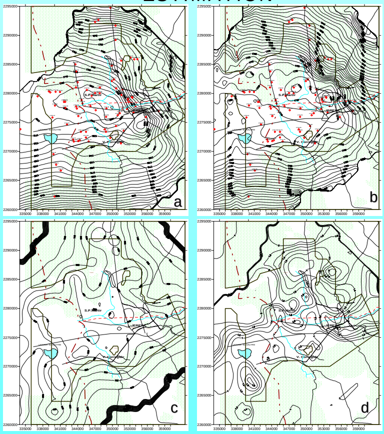

Fig. 10, a) OK; b) COK; c) COK variance; d) OK variance/ COK variance.

CONCLUSIONS

For both applications, the improvement in the contour map for the phreatic level obtained by cokriging indicated by figure 5d and figure 10d is of 14%, also the values of the error variances is reduced.
For the Mexicali case the COK estimation and the OK estimation are very similar. This could be due to the low variability of both variables.
For the Queretaro case, in contrast, the COK estimation has greater changes that define in a beter way the directions of flow in the Obrajuelo and Salitre zones.

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