

Airborne Electromagnetic Data as External Variable to Predict Groundwater Electrical Conductivity in the Crystalline Domain of Irauçuba Region - Ceará, Brazil

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REFERENCES

- Geostatistics**
- Deutsch, C. V.; Journel, A. G. *Annealing Techniques* Techniques Applied to the Integration of Geological Geological and Engineering Data, Stanford Center for Reservoir Forecasting, Stanford, USA: Stanford University, 1992. (Report 5).
 - Wackernagel, Hans. 1995 – External Drift. In: *Multivariate Geostatistics - an introduction with applications*. Springer-Verlag Editora, Berlin. p.190-p.190-200.
 - Oliveira, M. L. de. 1997 - Análise das Incertezas Envolvidas na Modelagem de Reservatórios no Contexto Geostatístico. Dissertação de Mestrado. UNICAMP, Campinas, São Paulo. 116 p.
- Study Area (Geology and Hydrogeology)**
- Feitosa, F. A. C.; Manoel Filho, J. 2000 – Hidrogeologia Hidrogeologia – Conceitos e Aplicações. [Coordenado [Coordenado por], Fortaleza. CPRM/REFO, LABHIIH-LABHIIH-UFPE, 2a. Edição. 391 p.
 - LASA ENGENHARIA E PROSPECÇÕES S/A. 2001 - 2001 - Projeto Aerogeofísico Água Subterrânea no Nordeste do Brasil. Blocos Juá (CE), Samambaia (PE) e (PE) e Serinha (RN). 2001 - Relatório final do levantamento e processamento dos dados magnetométricos e eletromagnetométricos e seleção das anomalias eletromagnéticas. Cooperação Cooperação Canadá-Brasil, 3 volumes, 3 CD-Rom.
 - Oliveira, R. G. de; Souza Filho, O. A. de; Ribeiro, J. A.; A.; Oliveira, R. G. de; Veríssimo, L. S. 2002 – Área-Piloto do Juá - Interpretação e correlação geológica dos dados geofísicos. CPRM/ Projeto Água Subterrânea Subterrânea no Nordeste do Brasil – PROASNE. Relatório Interno. Fortaleza. 35 p. il.
 - Souza Filho, O. A. de; Ribeiro, J. A.; Veríssimo, L. S.; S.; Oliveira, R. G. de; Gomes, F. E. M.; Brandão, R. de L.; Frizzo, S. J.; Oliveira, J. F. de. 2002 - Projeto Otimização de Metodologias para Prospecção de Águas Águas Subterrâneas em Rochas Cristalinas. Relatório Relatório Integrado De Atividades 1999 – 2002 - Bases Bases para avaliação do projeto. CPRM/REFO, Fortaleza. 160 p. il. Anexos.

THE STUDY AREA



School truck



Usual dessalinator system



Landscape over paragneiss



Landscape over orthogneiss and migmatites

GEOSTATISTICAL APPROACHES

EXTERNAL VARIABLE CONCEPT

Variables acquired by different ways but reflecting the same phenomena (physically related in nature), and and broadly distributed at the same spatial domain.

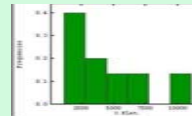
$$\begin{cases} \sum_{i=1}^n \lambda_i (x_i|Cv)(x_i - cv) + \mu(x) = \mu(x|Cv) = Cv(x - cv) & \text{eq (1)} \\ \sum_{i=1}^n \lambda_i = 1 & \text{eq (2)} \\ \mu & \text{eq (3)} \end{cases}$$

Being:
 λ_i = weight for each estimated j point in relation to i ; $i=1,2,...,n$
 $\mu(x)$ = primary variable second order stationary function;
 $\mu(x|Cv)$ = estimation function for which weight sum results unity;
 $\mu(x)$ = secondary variable function to describe a noise structure for the primary variable.

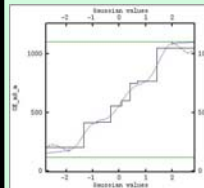
The estimative variance for the system eqs. (1) is

$$\sigma_{\hat{\mu}}^2(x) = C_v(x) - \sum_{i=1}^n \lambda_i C_v(x_i)(x_i - \mu) + \mu(x) - \mu(x|Cv)$$

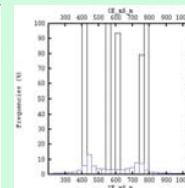
PREPARING WELL DATA FOR SIMULATION



A)



B

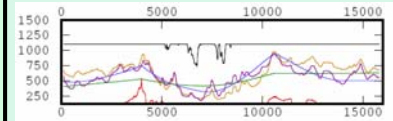


C)

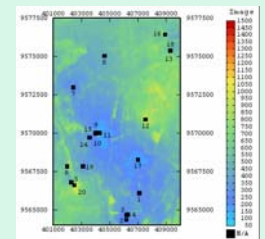
Electrical Conductivity for wells data

- A) original histogram for EC; data;
- B) Anamorphosis function applied the original data;
- C) histogram of the new Gaussian data (purple class) with weights from de-clustering (black classes).

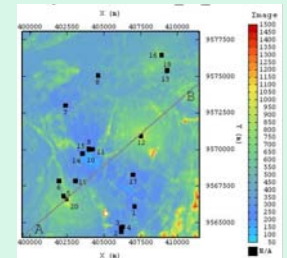
COMPARING SIMULATION AND KRIGING PRODUCTS



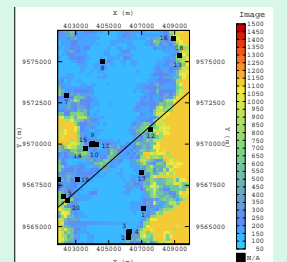
Ordinary Kriging (Blue);
 Non-stationary E-W; Kriging (Dark Green);
 External Drift Kriging (Purple);
 Mean of 100 Ext. Drift Simulations (Yellow);
 Max 100 ext. Drift Simulations (black);
 Min. 100 Ext.Drift Simulations (red);



Mean of 100 simulations



Kriging with HEM as External drift



Non-Stationary EW Kriging