Multivariate Geostatistics for Mapping of Transmissivity and Uncertainty in Karst Aquifers

Thiago dos Santos Gonçalves, Harald Klammler *, Luíz Rogério Bastos Leal and Lucas de Queiroz Salles

Institute of Geosciences, Federal University of Bahia, Salvador 40170, Brazil; t.gon@outlook.com (T.d.S.G.); lrogerio@ufba.br (L.R.B.L.); lucassalles2008@gmail.com (L.d.Q.S.)
* Correspondence: hklammler@ufba.br

1. Supplementary information

In Figure S1a, we present a simplified hydrogeological map representing the SKA, equipotential lines, and the main flow directions. A Digital Elevation Model is presented in Figure S1b, while Figures (S1d, S1e, S1f, S1g) show vertical hydrogeological sections.

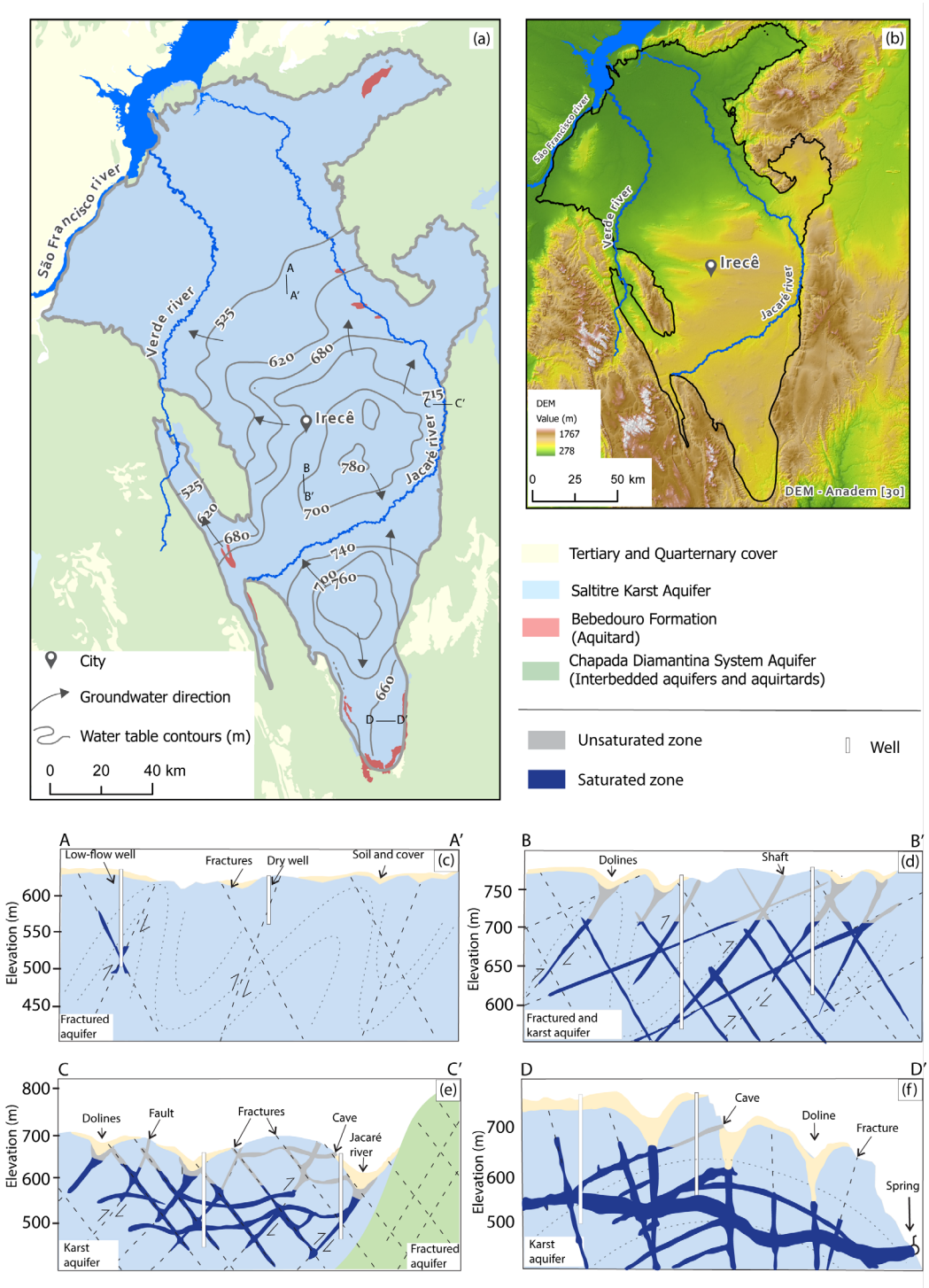

Figure S1. (a) Hydrogeological map. (b) Digital Elevation Model [1]. (c, d, e, f) Hydrogeological sections.

In Figure S2, we present the variogram of transmissivity ($\log T_{emp}$) generated from specific capacity data. It is omnidirectional with an exponential structure, a sill of 1.17, a nugget effect of approximately 50% of the sill, and a range of 3 km.

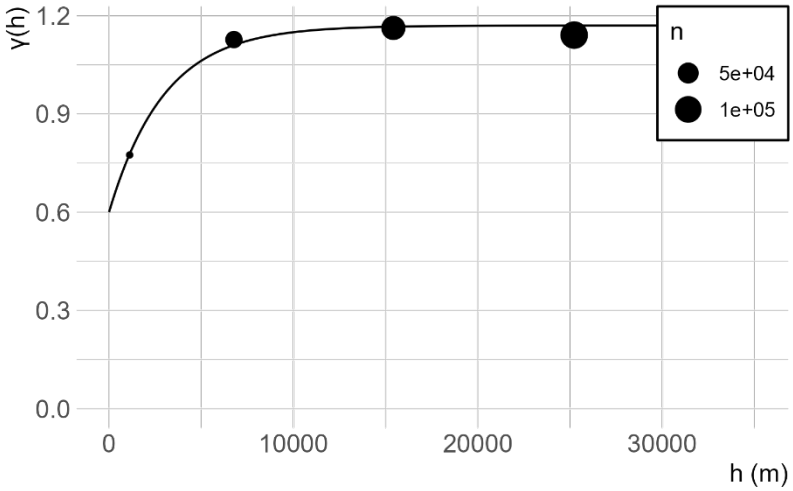

Figure S2. Variogram of logT_{emp}.

The ordinary kriging of logT_{emp} values and the associated standard deviations are presented in Figure S3a and Figure S2b, respectively. The logT_{emp} values range from -0.88 m²/d to 3.03 m²/d, with a standard deviation ranging from 0.8 to 1.1.

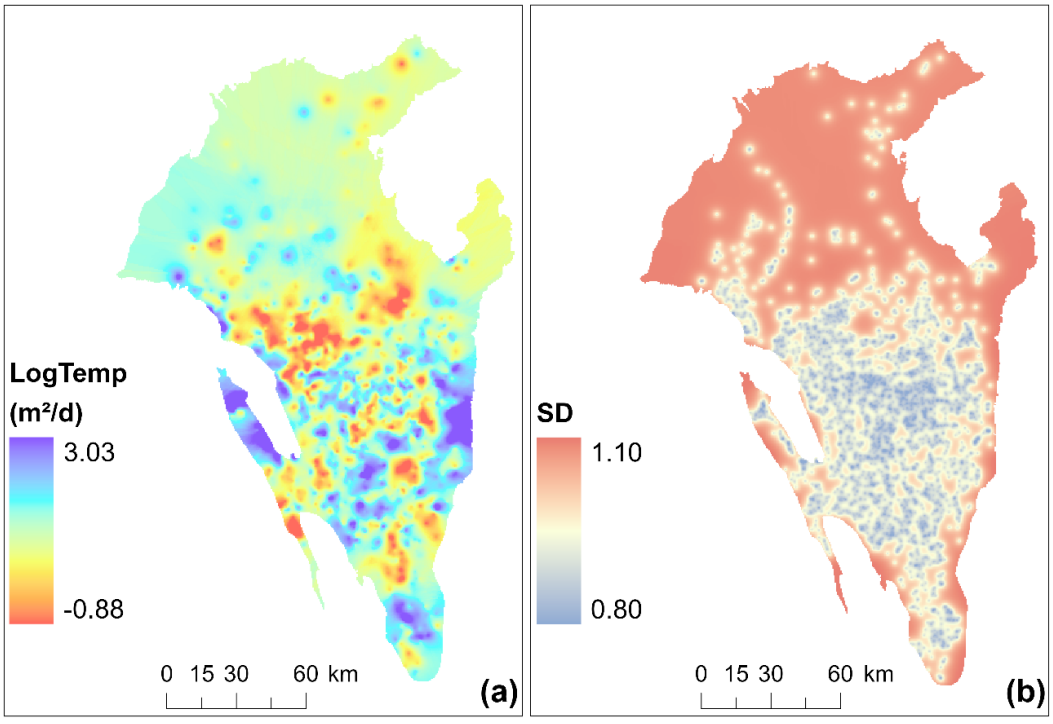

Figure S3. Interpolation of logT_{emp} values. (a) Ordinary kriging, and (b) standard deviations from ordinary kriging.

The means and standard deviations of the 500 stochastic realizations are shown in Figures S4a and S4b, respectively. The logT_{emp} values range from -0.84 m²/d to 3.07 m²/d, with standard deviations ranging from 0.75 to 1.24.

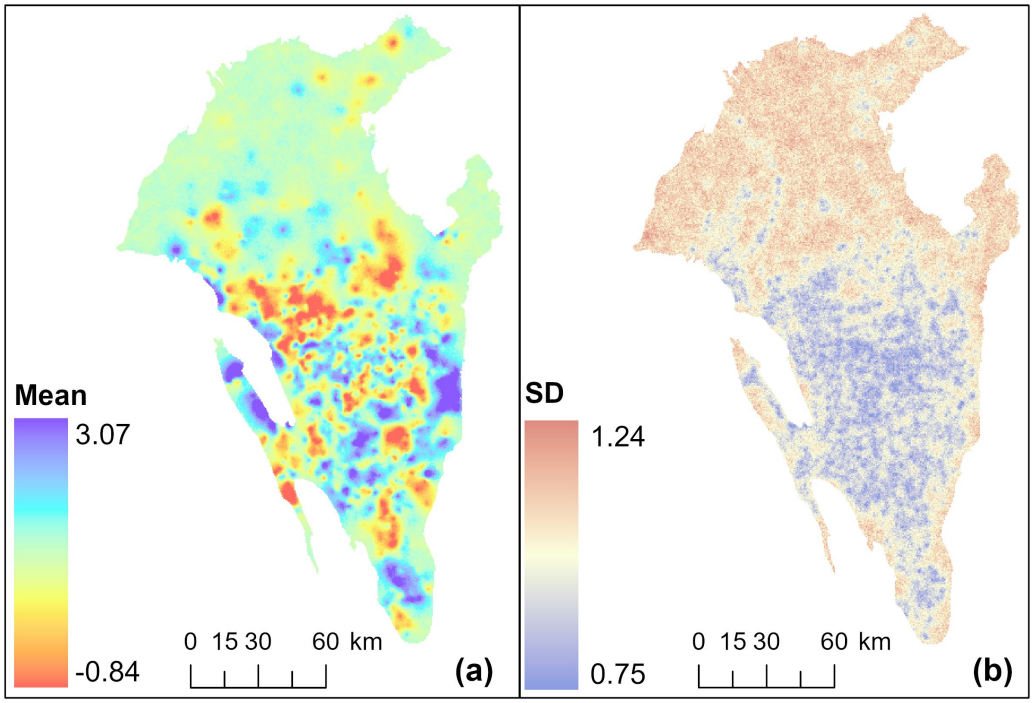

Figure S4. Maps derived from 500 stochastic realizations of logT_{emp}. (a) Means and (b) standard deviations of the realizations.

In Figure S5 we correlate data on geomorphological features with measured values of log$T$ at the locations of the 174 wells used in this study. We understand that these parameters could be indicators of higher or lower transmissivity values potentially useful as alternative secondary (or terciary) variables. However, none of these parameters showed a reasonable linear correlation with the log$T$ values.

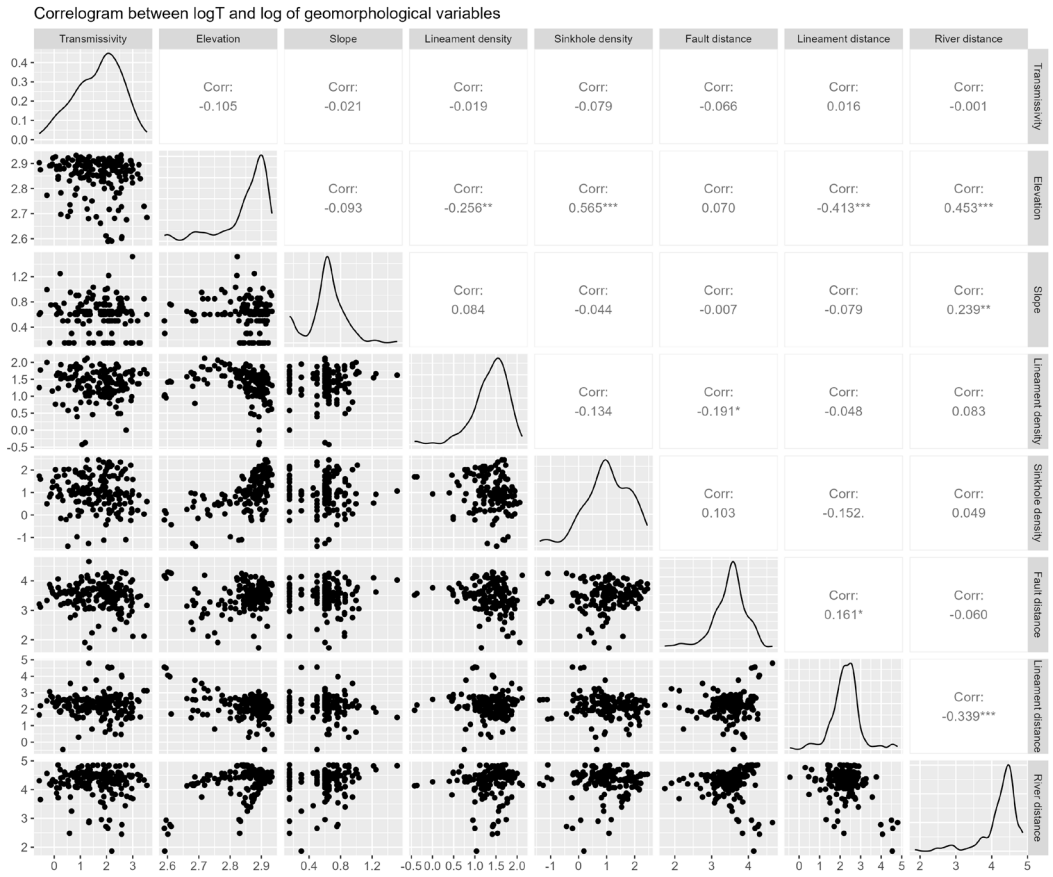

Figure S5. Correlogram between log$T$ and geomorphological variable values (logarithmic) in the SKA.

In Figure S6a, we show that zones with log$T$ > 2.5 m²/d contribute to maintaining perennial sections in the Verde and Jacaré rivers. In Figures S6b and S6c, we present the variation in river flow from 1980 to approximately 2010. Figures S6d and S6e are hydro-geological sections drawn near the streamflow monitoring stations.

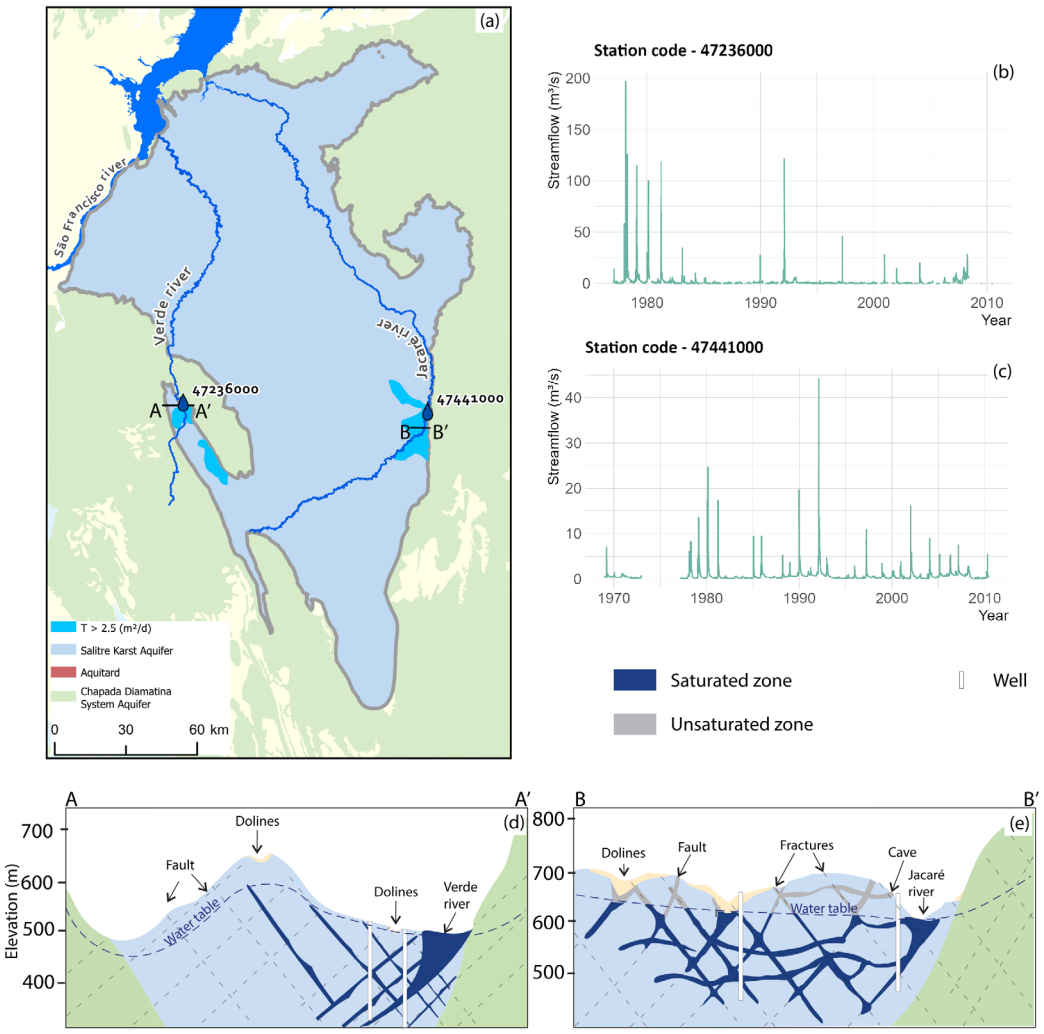

Figure S6. SKA high transmissivity zones and flow regimes of the Verde and Jacaré rivers. (a) Map of the SKA highlighting zones with logT > 2.5 m²/d near streamflow monitoring stations. (b, c) Streamflow data from the monitoring stations [2]. (d, e) Hydrogeological sections near the stations showing the intermittent Jacaré River under flowing conditions, as opposed to dry conditions in Figure S1c.