Comparing two basic approaches to decorrelation transforms

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Decorrelation / whitening transforms

Consider a multivariate statistical problem involving N correlated variables, stored in the vector $\boldsymbol{x}$.

Decorrelation is a coordinate transformation $\boldsymbol{y} = \boldsymbol{Lx}$, where $\boldsymbol{L}$ is designed to satisfy:

$$\boldsymbol{LCL}^T = \boldsymbol{I},$$

where $\boldsymbol{C}$ is the covariance matrix. There are 5 common options:

$$\boldsymbol{L}_{zca}, \boldsymbol{L}_{pca}, \boldsymbol{L}_{chol}, \boldsymbol{L}_{zcacor}, \boldsymbol{L}_{pcacor},$$

…which are based on eigen-decompositions or Cholesky factorizations of $\boldsymbol{C}$.

In 2020, CREWES published an alternative approach based on a geometrical view (i.e., devising a coordinate transform whose basis vectors form an oblique-rectilinear system).

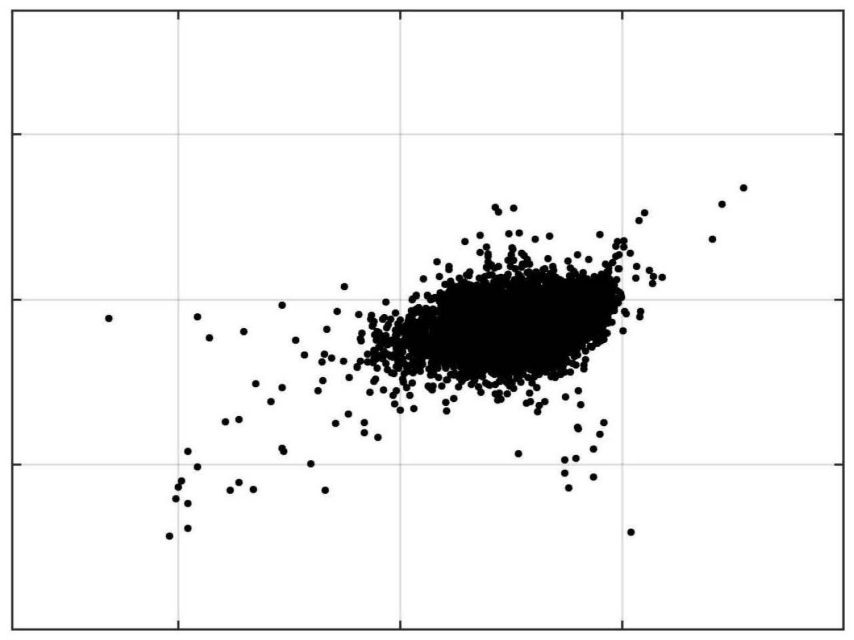
It is solved by supplying from geometrical arguments the lower-triangular elements of a new $\boldsymbol{L}$. For instance, in the $N = 4$ case, we supply the l^*_{ij}, where

$$\mathbf{L}_g = \begin{bmatrix} l_{11} & l_{12} & l_{13} & l_{14} \\ l^*_{21} & l_{22} & l_{23} & l_{24} \\ l^*_{31} & l^*_{32} & l_{33} & l_{34} \\ l^*_{41} & l^*_{42} & l^*_{43} & l_{44} \end{bmatrix}$$

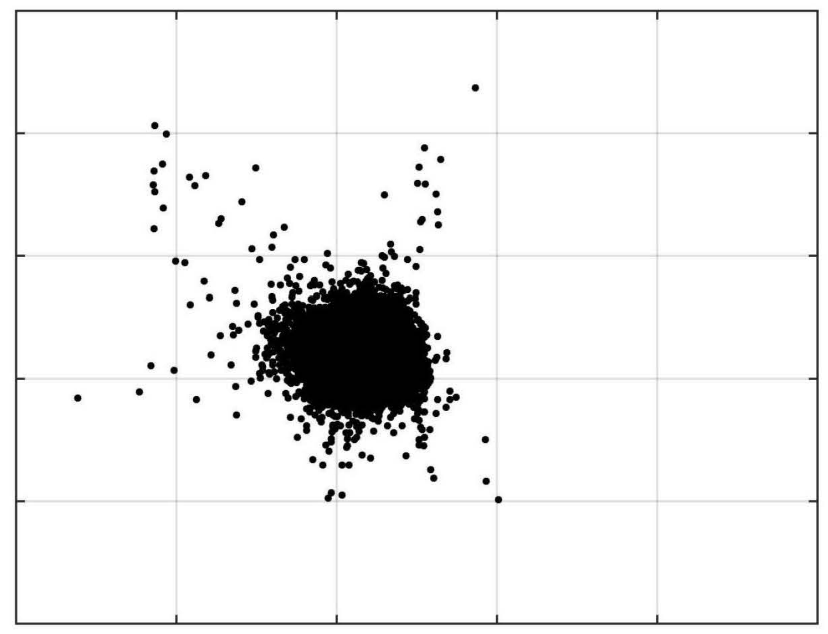
after which the diagonal and upper triangular elements are determined.

Analysis based on non-Gaussian data

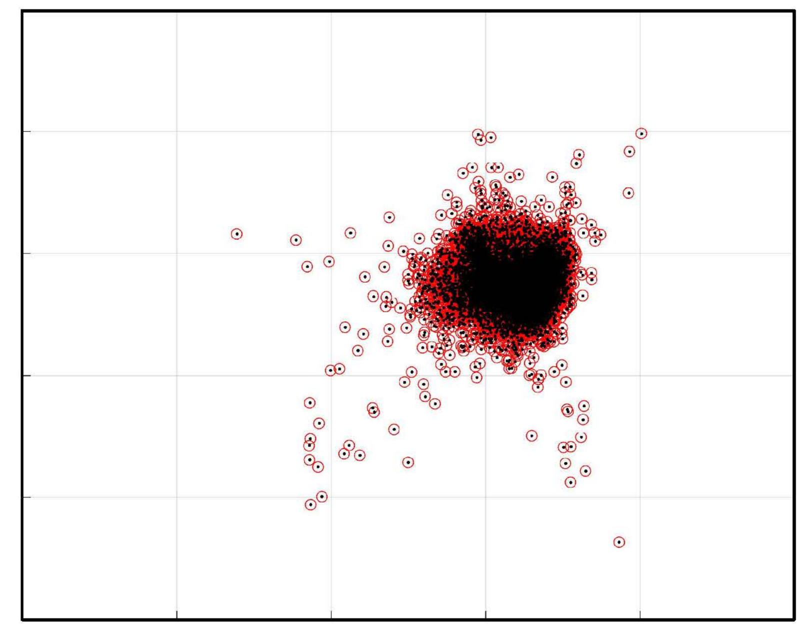
To compare different approaches, non-Gaussian, bivariate well log data are employed. Closest relative is ZCA (after matching, rotation, reflection). Computationally the geometric approach appears to have several advantages.



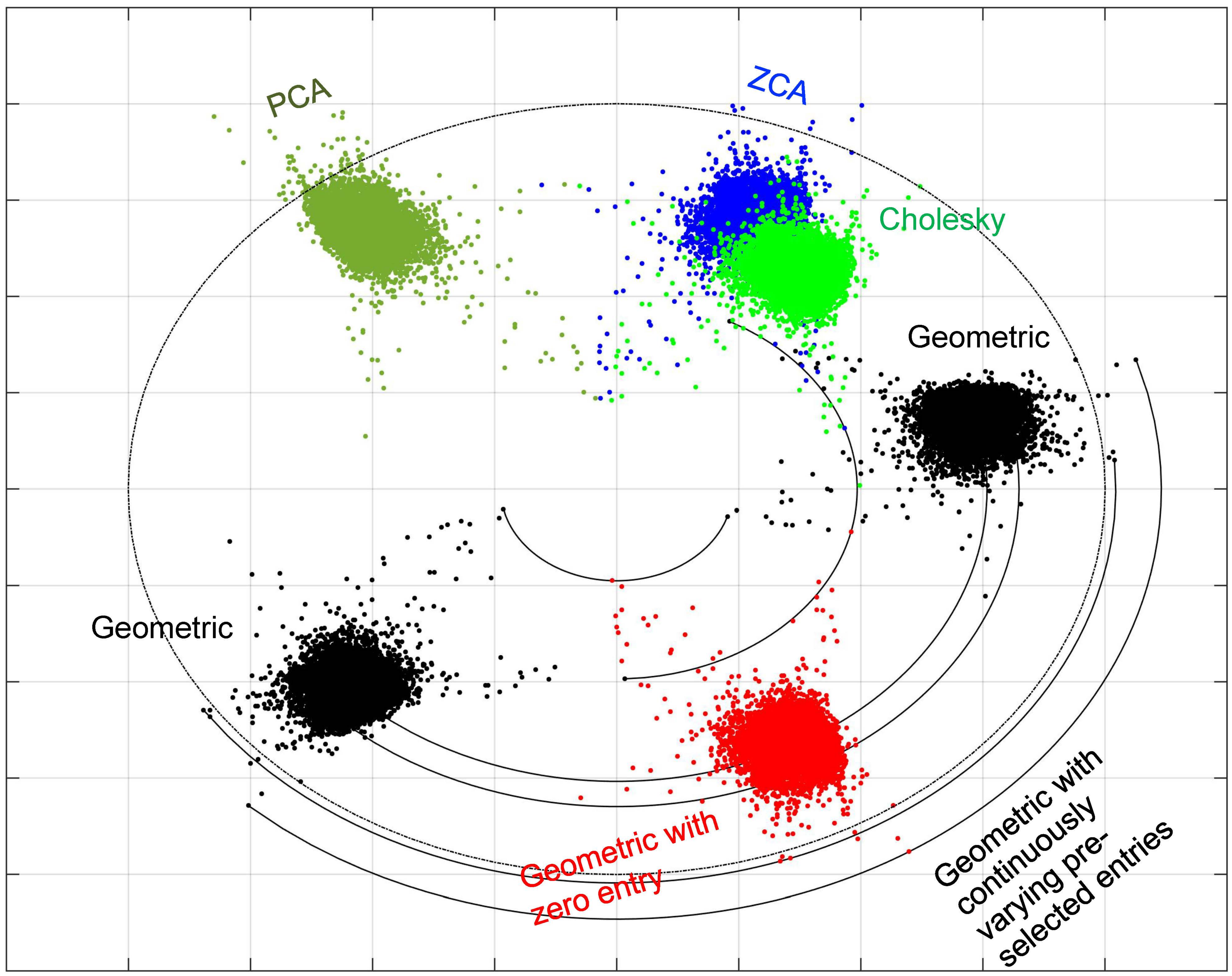
Original well log data



Geometric decorrelation



Geometric vs ZCA



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