PostMG: A Postprocessing Program for Multigaussian Kriging Output

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Abstract

Multigaussian kriging works by first transforming a distributed data set $z(\boldsymbol{u}_\alpha)$, $\alpha=1,...,n$ to normal scores $y(\boldsymbol{u}_\alpha)$, $\alpha=1,...,n$. Inference is performed using these transformed values under the assumption of Gaussianity, where all distributions are fully defined by their means and variances. Kriging in multigaussian space is carried out with the global mean set to m=0 and a global variance of $\sigma^2=1$. Once kriging is performed, the original distribution and units can be restored by a back transform. The estimation variances can also be back transformed to express the local uncertainty in the same units as the estimates. The back transform involves first transforming the local data to match the transformed global distribution (i.e. m=0, $\sigma^2=1$), transforming to the global distribution of the original data, and finally transforming to the local distribution. This transformation process is shown in Figure 1.

The GSLIB software can be used for most steps related to multiGaussian kriging. NSCORE/BACKTR can be used for transformation and back transformation. GAMV/KT3D can be used for kriging. There is a need, however, for a little postprocessing program to take the results of multiGaussian kriging and calculate summary measures of uncertainty.
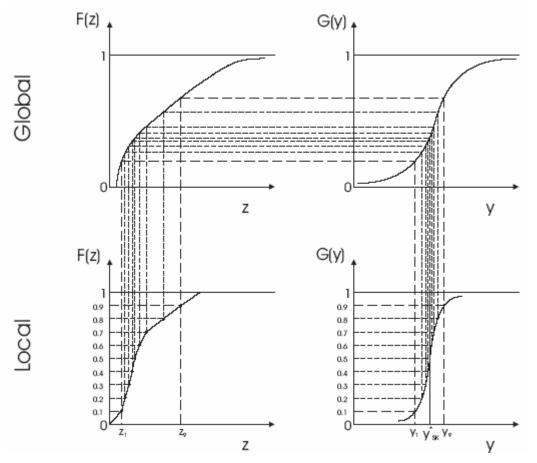
Program

`PostMG` was written to perform the back transform of kriged multigaussian output. The program requires a file with the kriged mean and variance in standard `GSLIB` format and a transformation table derived from the original data. The transform table comes from `NSCORE` and must be monotonic increasing. The back transformed mean and variance are output to a user-specified file along with probability for the location to be within some percentage of the mean value and specified quantile values. The following parameters are required:

```
Line    START OF PARAMETERS:
1       kt3d.out                      -file with kriged NS mean and variance
2       1  2                          -  columns with NS mean and variance
3       PostMG.out                    -file for output
4       nscore.trn                    -file with input transformation table
5       15                            -probability to be in +/-XX% of mean
6       5                             -number of quantiles to keep
7       0.05  0.10  0.50  0.90  0.95  -   the probability values
```

Line 1 contains the name of the kriging output file, which is used for input by `PostMG`; **Line 2** has the columns for the data in this file. **Line 3** is the name of the file for back transformed output. **Line 4** is the normal score transform table derived from the original data. **Line 5** is a user-specified percentage deviation from the mean: `PostMG` will output the probability of each point

to be within this percentage of the expected value. Specified in **Line 6** is the number of quantiles to be output by the program. The quantile values are in **Line 7**. `PostMG` will give the $z(\mathbf{u}_\alpha)$ quantile values corresponding to these cumulative probabilities at each location in the output file. Outputting the quantiles makes it simple to analyze the shape of the conditional distribution and probability above or below a cutoff at each location.

Figure 1: The transformation process used by `PostMG`. Working from the lower right distribution of the local multigaussian (G(y)) distribution, the values are transformed to the global G(y) distribution, then the global F(z) distribution of the original data, then finally the local F(z) values are found for the various quantiles. The local mean and variance are found from these quantiles (Source: Ortiz, 2003).

Example

Shown in Figure 2 is a location map of a set of rainfall data. There are 467 data values that range from 0 to 585. The clustered and declustered histograms of the data are shown in Figure 3. The data was kriged without using a normal scores transform, then multigaussian kriging was performed to compare.
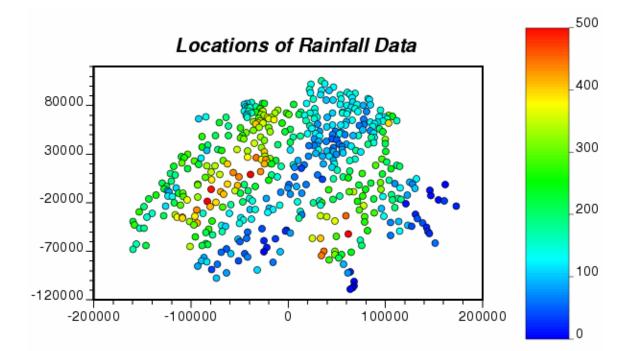
Figure 2: Location map of a set of rainfall data (`alldata.dat`).
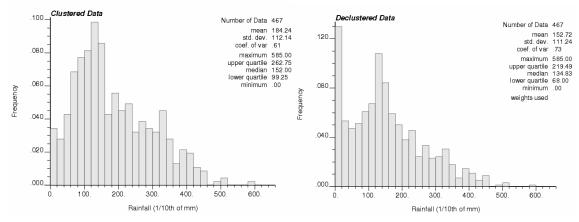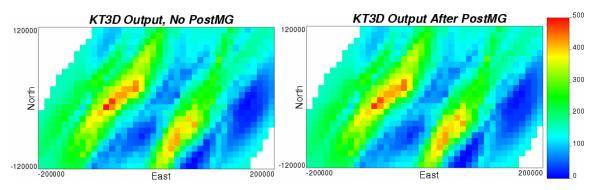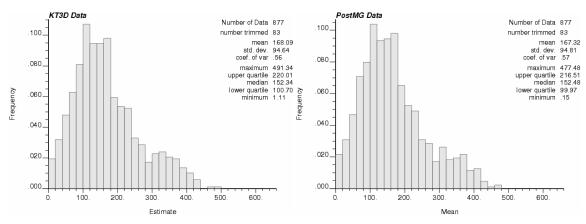

Figure 3: Histogram of the data (left) and declustered histogram (right).

Figure 4 shows maps of the results of simple kriging and multigaussian kriging followed by `PostMG`. The results were very similar, as is made obvious by looking at the maps. Histograms of the kriged values from each method are shown in Figure 5.

Figure 4: Kriged estimate maps from `KT3D`. Left: Simple kriging results without performing a normal scores transform prior to kriging. Right: Results from multigaussian kriging followed by using `PostMG`.

Figure 5: Histograms of the kriged values shown in Figure 4. Left: KT3D output without a normal scores transform. Right: PostMG output after multigaussian kriging.

The mean results are very similar in both cases. Where `PostMG` improves the quality of simulation is in the back transforming of variances. The kriged normal scores variances are properly back-transformed and may be used easily to analyze uncertainty. Figure 6 shows histograms of the variances returned by `KT3D` and `PostMG`. Notice that the `KT3D` output variances are still in normal score form; the `PostMG` variances are in the correct units and are ready to be used for uncertainty assessment directly.
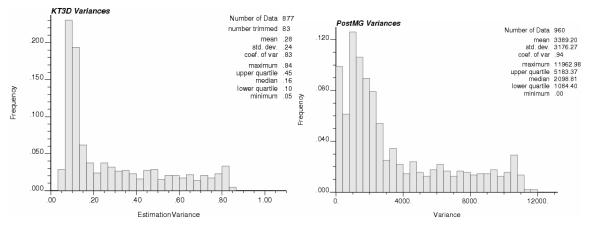
Figure 6: Variances returned by `KT3D` (left) and `PostMG` (right).

Discussion

While `PostMG` doesn't improve the quality of kriged estimates by a noticeable margin, the multigaussian transformation makes inference of conditional distributions remarkably simple. The use of a back transform to restore the statistical distribution of the original data allows determination of probability to be above or below a cutoff for reserve estimation. `PostMG` also returns the correct variances for each estimated point.

References

1. T. Anderson. *An Introduction to Multivariate Statistical Analysis*. John Wiley & Sons, New York, 1958.

2. C.V. Deutsch and A.G. Journel. *GSLIB: Geostatistical Software Library and User's Guide*. Oxford University Press, New York, 2nd Edition, 1998.

3. J.M. Ortiz and Clayton V. Deutsch. Uncertainty Upscaling. In *Centre for Computational Geostatistics*, Volume 5, Edmonton, AB, 2003.