Geovariances
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White Paper



Localized Multivariate Uniform Conditioning

LMUC

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Localized Multivariate Uniform Conditioning (LMUC)

Estimate recoverable resources at mining unit scale.

Estimating tonnage and grade, from sparse data, at a mining scale resolution is a challenge.

Uniform Conditioning (UC), provides a powerful approach to estimating recoverable resources at a local scale, i.e. predicting the local distributions of SMUs (selective mining units) within larger panels conditional to neighbouring information.

UC is applicable in multivariate settings, paving the way for powerful resource and product characterisation as the grades recovered for secondary metals can be predicted when a cut-off is applied to the primary metal of interest.

The resulting model is therefore better aligned with mine planning constraints and offers increased confidence in future scheduling of the mining operation.

UC has been successfully applied worldwide by Geovariances for over 15 years.

UC was developed at the Geosciences Department / Geostatistics Group from Mines ParisTech in the 80's and formalised by Dr Jacques Rivoirard (current head of the research centre), who also worked on the mathematical framework required for the multivariate expansions that have been implemented in recent years.

Considering mining methods when modelling

Is your resource estimation aligned with your mine planning constraints?

In situ resource models based on exploration data will usually fail to capture the variability at the scale of selective mining units used for mine planning. In situ resource models are traditionally based on panel sizes that are compatible with the exploration drill spacing, and these panels are usually much larger than the size of the actual SMUs. The prediction of recoverable tonnes and grade based on in situ resources, on the panel-scale, may distort the quantities actually recoverable from the mining process e.g. at the SMU-scale (see figure below).

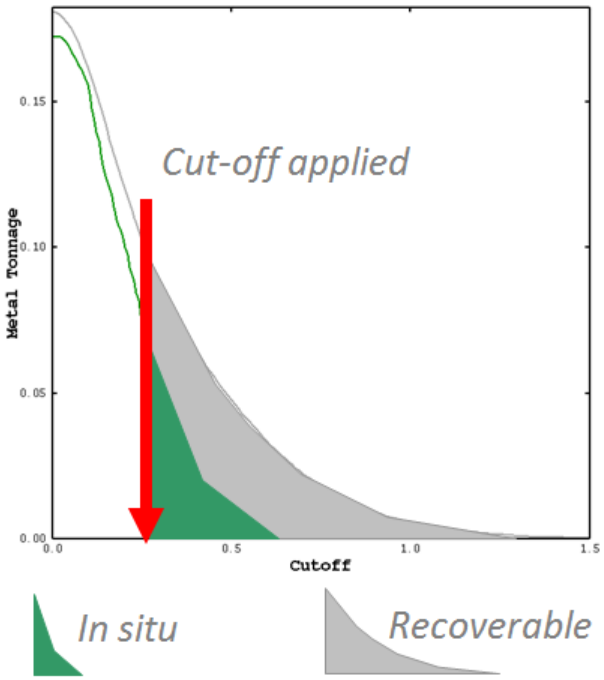


Fig. 1 – Recoverable resource estimates may distort at the SMU-scale

Benefits

UC is the optimal solution to capture the orebody's response to mining selectivity constraints and, as a result, will enhance the prediction of the economic performance of the mine site.

Uniform conditioning for unbiased results

Take the mining selectivity constraints into account.

Whilst estimating SMU grades from sparse exploration drilling is not defensible geostatistical practice ("one shall not estimate small blocks"), the realm of recoverable resource estimation offers a different type of solution: it fulfils the practical objective of evaluating the economic performance of the deposit under fixed selectivity constraints.

Implementing UC estimates the distributions (or histograms) of SMU grades on different scales:

- at the deposit scale, in global recoverable resource estimates; and
- at the panel scale, for local recoverable resource estimates.

UC is one methodology amongst many to achieve such an objective. The advantage of UC is that it is particularly suited to orebodies that follow a diffusive model of grade architecture. In addition, being an extension of ordinary kriging, UC deals well with departures from strict stationarity conditions.

UC relies on the underlying assumption that the spatial grade distribution can be best described by a diffusion model, where grade tends to move from lower to higher values in a relatively continuous way: when going from higher to lower grade regions within a domain, we tend to pass through intermediate grades (and vice versa). The validity of this critical assumption can actually be tested on the data.

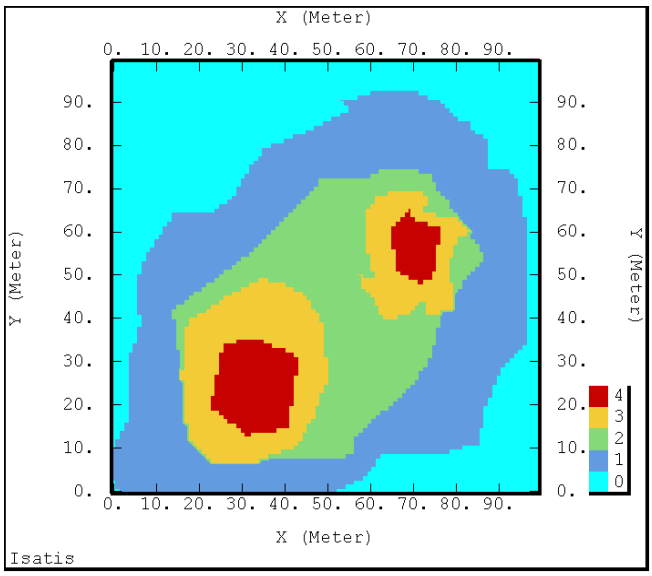


Fig. 2 - UC relies on the underlying assumption that the spatial grade tends to move from lower to higher values in a relatively continuous way

References

- M. O'Connor (CSA Global), O. Bertoli (Geovariances) and M. Titley (CSA Global)
  Estimating Recoverable Uranium Resources using Uniform Conditioning – A Case Study on the Mkuju River Uranium Project, Tanzania
  The AusIMM International Uranium Conference 2012 – 13-14 June 2012

- J. Deraisme (Geovariances), W. Assibey-Bonsu (Gold Fields)
  Localised Uniform Conditioning in the Multivariate Case: An Application to a Porphyry Copper Gold Deposit
  35th APCOM Symposium – 26-30 September 2011

Success Stories

1. Goldfields Cerro Corona Mine: Cu-Au porphyry miscellaneous preparatory test work in 2010 and resource estimation updates in 2011 2012 2013.
2. Goldfields Artic Platinum Projects: Implementation in 2012 of a complete multi-domain multivariate recoverable resource estimation for two variable groups PGE's (Pd, Pt, Rh, Au) and base metals (Cu, Ni, Co, S) at Konttijarvi and Ahmavaara.

Localised Uniform Conditioning

One of the main drawbacks of recoverable resource estimates obtained by UC (or any other method for that matter) is the difficulty attached to the manipulation of the results. This has been mostly overcome thanks to the implementation of a simple algorithm (proposed by M. Abzalov in 2006) that allows the transformation of the grade tonnage curves into a single grade value attached to each SMU. These single grade values are determined so as to reconstitute the grade tonnage curves panel by panel.

LMUC methodology

For each domain the workflow is straightforward and can be easily automated within Isatis using advanced scripting procedures. The key steps per domain are:

1. Model the declustered multivariate sample histogram;
2. Model the weighted multivariate variograms;
3. Perform multivariate change of support (point to SMUs) for the histograms;
4. Run co-kriging of multivariate dataset, at panel scale;
5. Run co-kriging of multivariate dataset, at SMU scale (input to localisation procedure);
6. Run multivariate Uniform Conditioning;

Run localisation of results and export for optimisation.

Limitations

The product characterisation obtained in LMUC still relies on the cut-offs being applied to a single grade (possibly a compound equivalent grade). LMUC does not provide an answer for complex multivariate selection criteria.

The characterisation of uncertainty attached to the recoverable resource estimation in LMUC is limited to the uncertainty attached to the panel kriged estimates. In order to assess the uncertainty attached to the recoverable resources at cut-off, the use of Multivariate Conditional Simulations is required.

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Who is Geovariances?

Geovariances is a specialist geostatistical consulting and software company. We have over 45 staff, including specialist mining consultants and statisticians.

Our software, Isatis, is the accomplishment of 25 years of dedicated experience in geostatistics. It is the global software solution for all geostatistical questions.

Other technical specialties

Geovariances are world leaders in developing and applying new and practical geostatistical solutions to mining operations. We have strong experience in all commodities, and have gained trust from the biggest international companies.

Our expertise is in applying geostatistics to resource evaluation. Our services are through consulting, training, and software.

Geovariances expertise

Geovariances has 15 years of experience in applying UC methodologies (UC and more recently LMUC) to orebodies worldwide, and training mining staff in its applications.

We can provide a unique expertise through both our French and Australian offices.

Geovariances is dedicated to applied geostatistics and has been providing the mining industry with premium software and consulting solutions for more than 25 years.

For more information

Let us help you optimise the accuracy of your predicted recoverable resource estimates and access the information you have available regarding recoveries predicted at the mining (SMU) scale.

Contact our consultants:

- In Australia, Clare Mawdesley: mawdesley@geovariances.com
- In France, Olivier Bertoli: bertoli@geovariances.com

Geovariances

49 bis, av. Franklin Roosevelt

BP91 - 77212, Avon Cedex

France

T +33 1 60 74 90 90

F +33 1 64 22 87 28

PO Box 979

Wynnum, QLD 4178

Australia

T +61 7 33 48 53 33