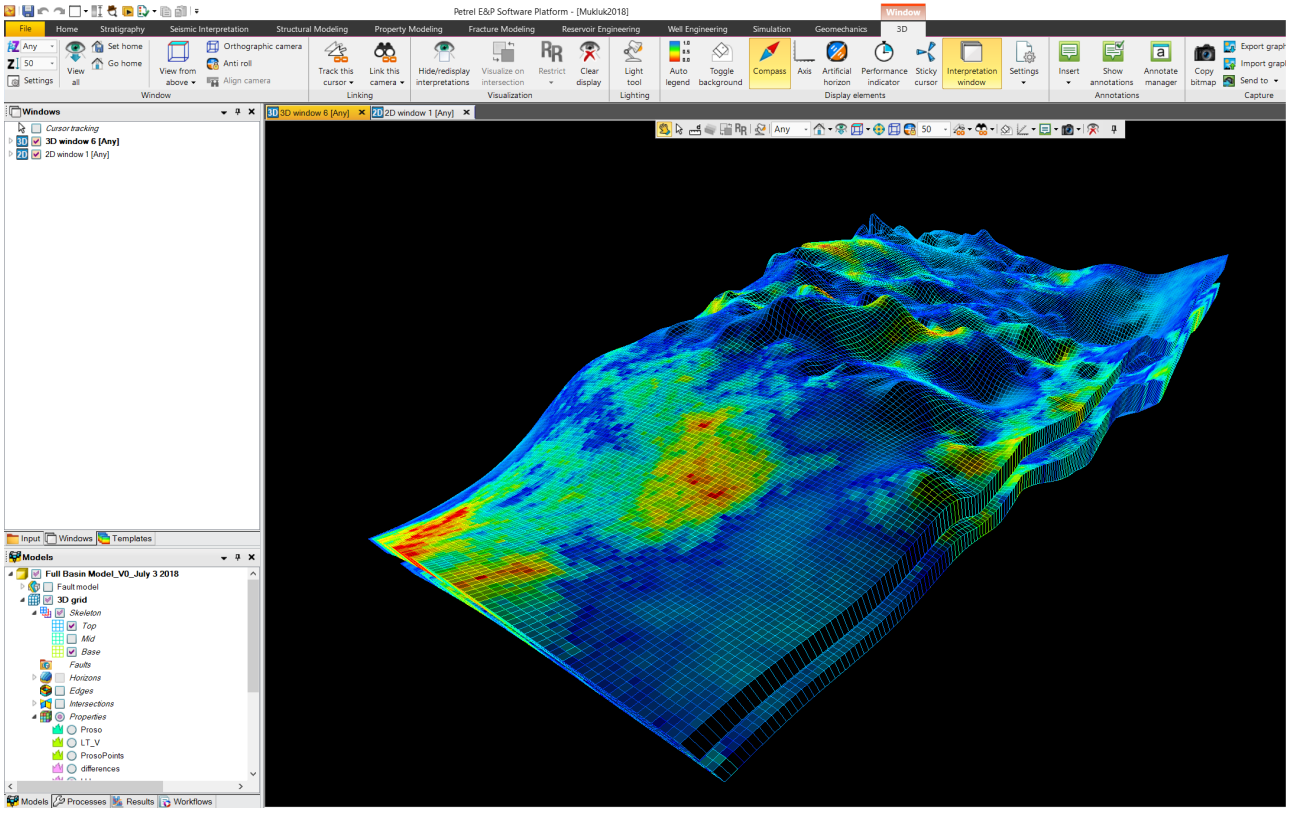
FINAL REPORT

The University Of Queensland
AUSTRALIA

Centre for Natural Gas

Impact of Geostatistical Techniques on Technically Recoverable Resources and Fluid Flow – Petrel Plug-in project



Project

This working document is the final report of the Impact of Geostatistical Techniques on Technically Recoverable Resources and Fluid Flow - Petrel Plug-in project (CLX 149360, UQ Project Number 022001).

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Disclosure

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The Australian Code for the Responsible Conduct of Research outlines expectations and responsibilities of researchers to further ensure independent and rigorous investigations.

This report has not yet been independently peer reviewed.

Document control sheet

Version #	Reviewed by	Revision Date	Brief description of changes
1.0			

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1 Executive summary

This is the final report for the Impact of Geostatistical Techniques on Technically Recoverable Resources and Fluid Flow - Petrel Plug-in project (CLX 149360, UQ Project Number 022001). In Stage 1, this project has investigated the impact of different geostatistical modelling strategies on subsequent flow modelling and estimation of volumes (rock, fluids). The copula approach has been thoroughly tested on a wide range of synthetic coal seam gas (CSG) examples. The finding from these tests have been described in the Stage 1 project report. This report also contains the theoretical background on geostatistics in general, copula geostatistics as well as the concept of spatial asymmetry. From Stage 1 it could be concluded that the choice of the geostatistical modelling approach (traditional vs copula-based with spatial asymmetry) has a significant impact on subsequent flow modelling and the estimation of volumes. Based on these findings, the project partners decided that non-linear copula geostatistics are a useful addition to the currently available approaches.

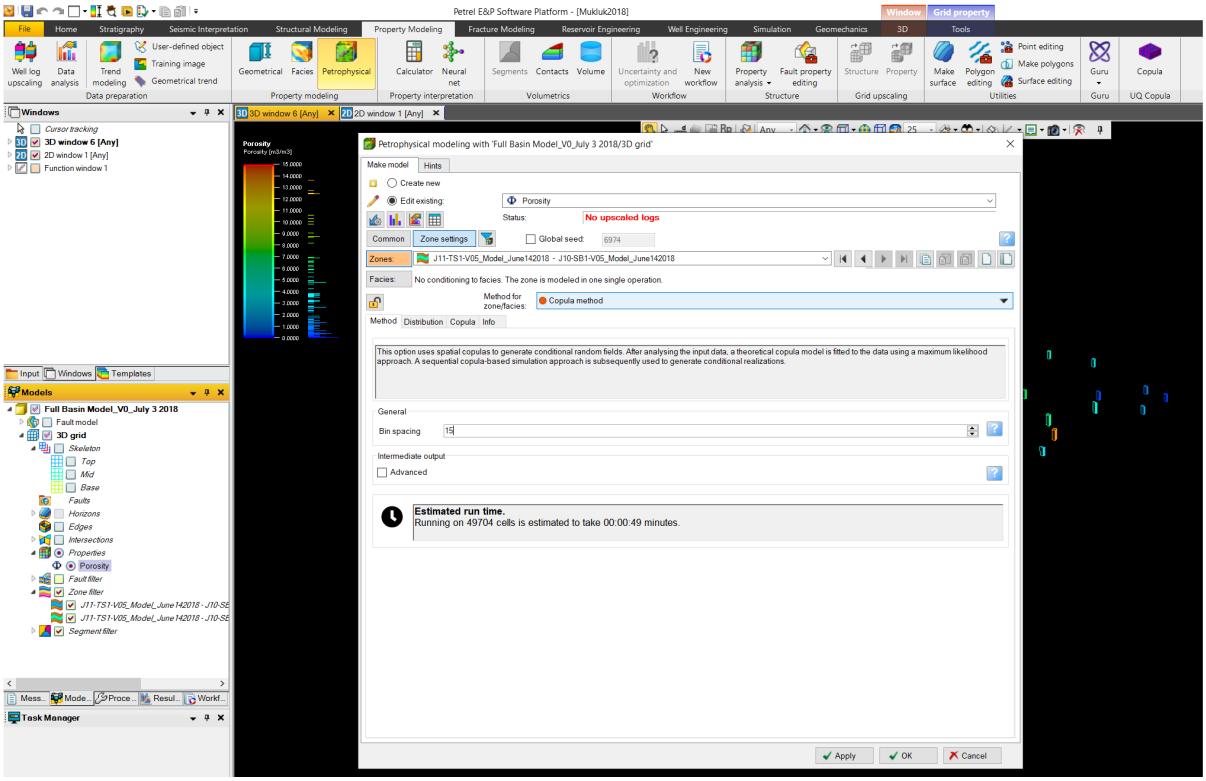
In Stage 2 of this project, an industry ready Petrel plug-in for non-linear copula based geostatistics has been developed which enables simple access to copula based geostatistics to UQ's industry partners as well as to a broader clientele. The Petrel plug-in has been developed in cooperation with PDS (Petrotechnical Data Systems Ltd). During the development phase, a beta version has been distributed to the member companies for internal testing and feedback. Following this feedback, the underlying source code and the plug-in itself has been optimized to improve its performance and increase its functionality. The technical details and particularities of the source code have been described in the Stage 2 progress report.

This final report provides a summary of the final release of the Petrel plug-in. An overview of its functionality is presented and links to all resources (installer files, terms of use, installation guides, overview documents and videos, reports and publication) that have been developed during this project are provided.

2 Petrel Copula Plug-in

The University of Queensland (UQ) has cooperated with PDS (Petrotechnical Data Systems Ltd) to develop the Petrel plug-in. PDS specializes in developing Petrel Ocean plug-ins and they were recommended to UQ by Schlumberger. The team at PDS has developed the interface and the GUI which links the plug-in source code to Petrel. As different Petrel versions are not compatible with each other, it has been decided to built plug-ins for Petrel 2017, 2018 and 2019. Their functionalities are identical, just their integration into Petrel had to be adjusted for each version independently.

The plug-in is integrated into Petrel's Property Modeling - Petrophysical Modeling functionality as shown in Figure 1.



Once the plug-in is installed, the 'Copula method' becomes available. All the other functionality within Petrophysical modeling is still available, e.g., Zone or Facies selection. After selecting the 'Copula method' the algorithm fits a marginal distribution to the selected data set. Fitting a marginal distribution means optimizing the parameters of available distribution functions such that they resemble the statistics of the data. Once the fitting process has finished, the GUI shown in Fig. 2 opens which shows the 'best fit'. The user can now interactively change the parameters of the selected distribution function and with that update the fit. Further, a different type of distribution function can be selected and its parameters can also be changed. Alternatively, the user can accept the 'best fit' and then the algorithm continues with the fitting of the spatial copula. Similarly to the distribution function fitting, fitting the spatial copula means optimizing the parameters of a spatial copula such that it represents the available data. After the fitting process, the window shown in Fig.

3 opens up, which shows the best fitting copula parameters and its statistics compared to the data.

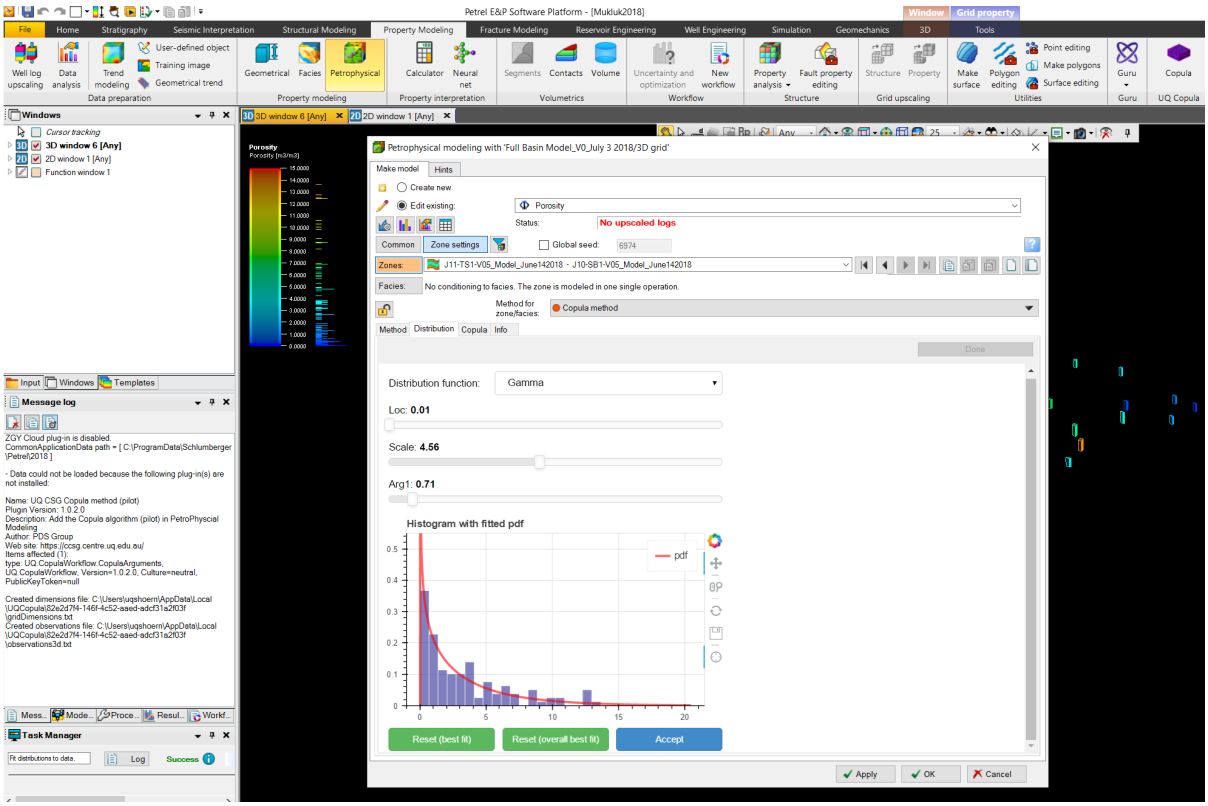


Figure 2: Interactive fitting of the marginal distribution.

Here, the user can again change the parameters and update the fit interactively. This will update the statistics (spatial rank correlation and asymmetry function) as well as a preview of a spatial random field that could result based on the selected parameters. After accepting the fitted or updated copula parameters, the plug-in starts the sequential copula simulation process. A progress bar within Petrel shows the estimated time required for the simulation (estimated as the simulation time depends on multiple factors that can vary between different computers etc.). Once the process is finished, the simulated field becomes available as a new property within the 'Model' window. Selecting this new property will display the simulated field as shown in Fig. 4. This field honors the data, the selected or fitted marginal distribution and the selected or fitted spatial copula. Since it honors the spatial copula, it also honors any spatial asymmetry that can be described by that copula. To obtain an ensemble of simulated fields (for example for subsequent uncertainty analysis etc.) the user can either restart the whole process manually or use the Petrel workflow manager and set up a workflow that will carry out the simulation repeatedly.

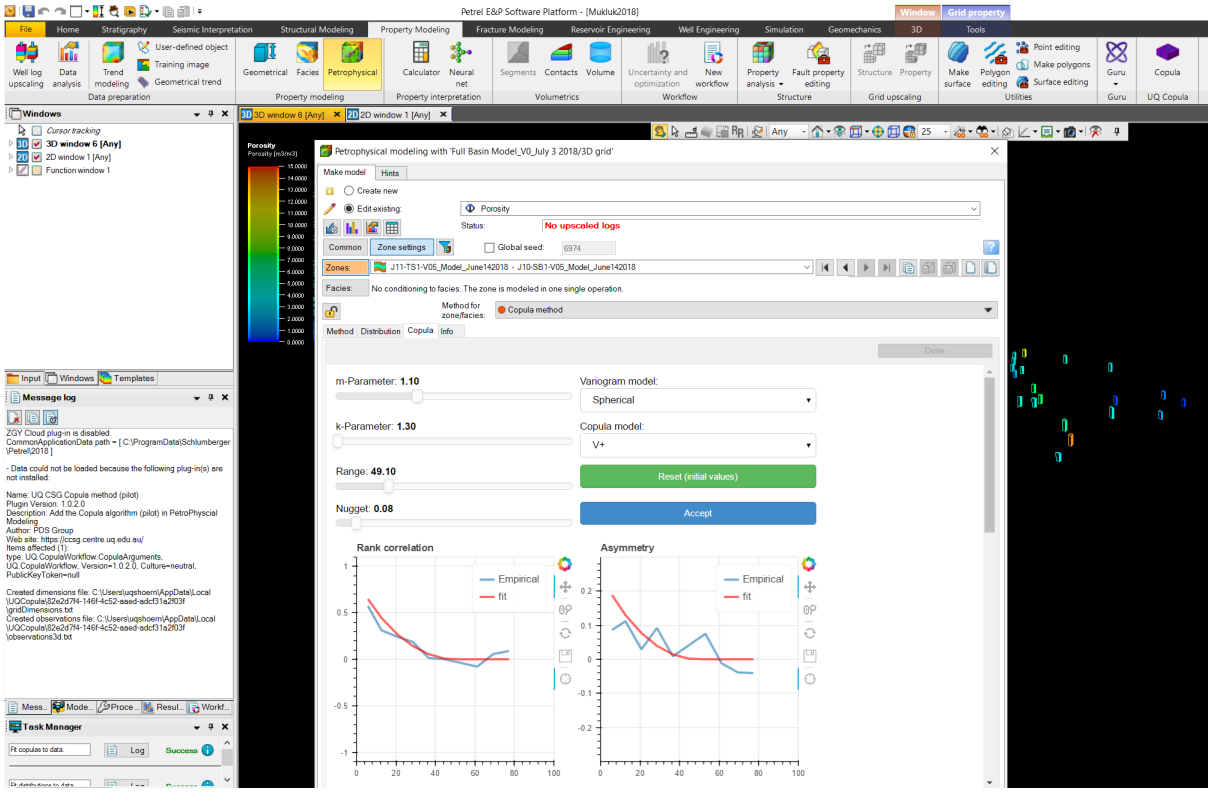


Figure 3: Interactive fitting of the spatial copula parameters.

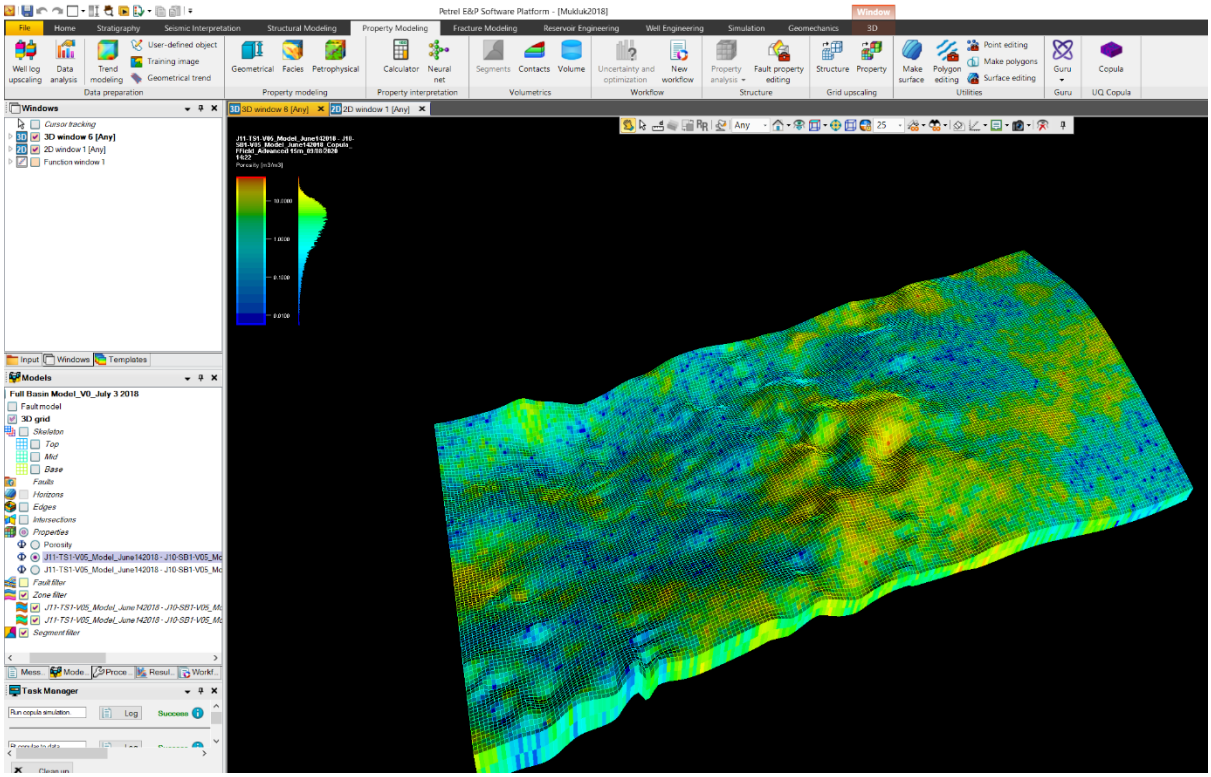


Figure 4: Plug-in simulation output.

3 Plug-in resources

An overview video and brochure (Fig. 5), describing spatial asymmetry and copula geostatistics in general is available at: https://natural-gas.centre.uq.edu.au/uq-copula-plug-in

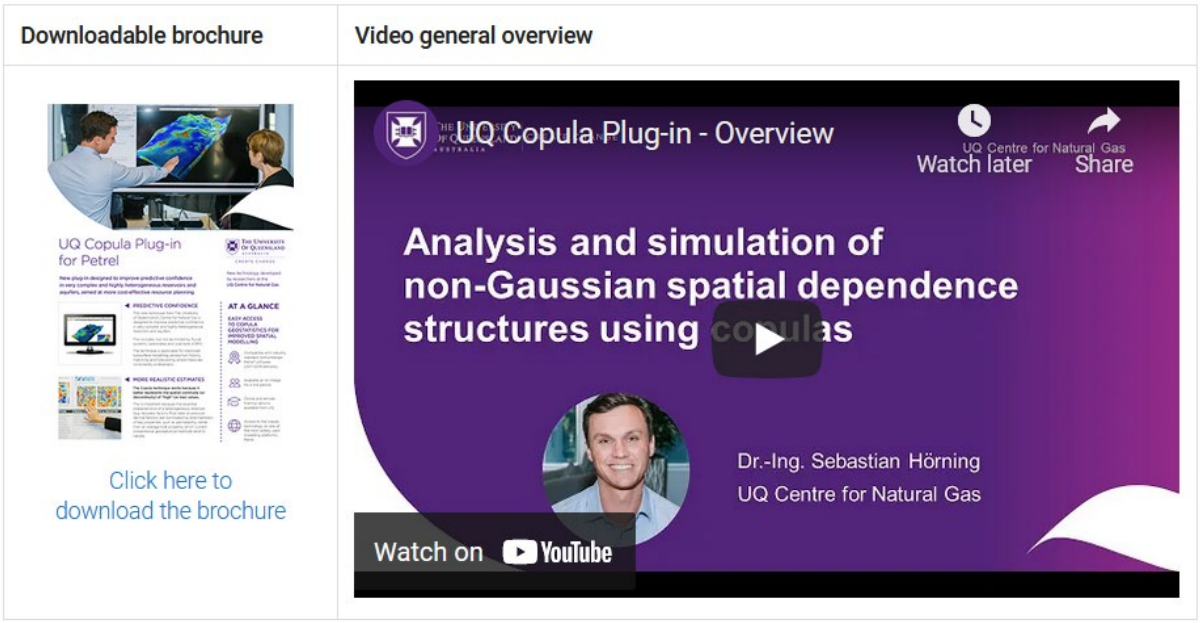


Figure 5: Overview brochure and video

The Petrel Copula Plug-in is available for Petrel 2017, 2018 and 2019. The general terms of use for members of the UQ Centre for Natural Gas as well as for non-members are available at: https://natural-gas.centre.uq.edu.au/files/10841/UQ-Copula-Plug-in-Terms-of-Use-members.pdf

and

https://natural-gas.centre.uq.edu.au/files/10838/UQ-Copula-Plug-in-Terms-of-Use-non-members.pdf

After agreeing to the terms of use, a link to the installer will be sent. Installation guides for each version of the Plug-in and an installation guide video (Fig. 8) as well as a user guide and corresponding video (Fig. 6) are also available at: https://natural-gas.centre.uq.edu.au/uq-copula-plug-in

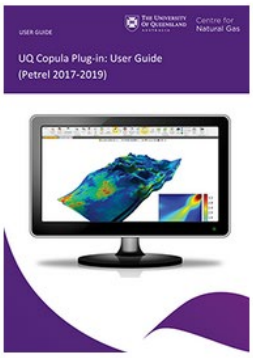
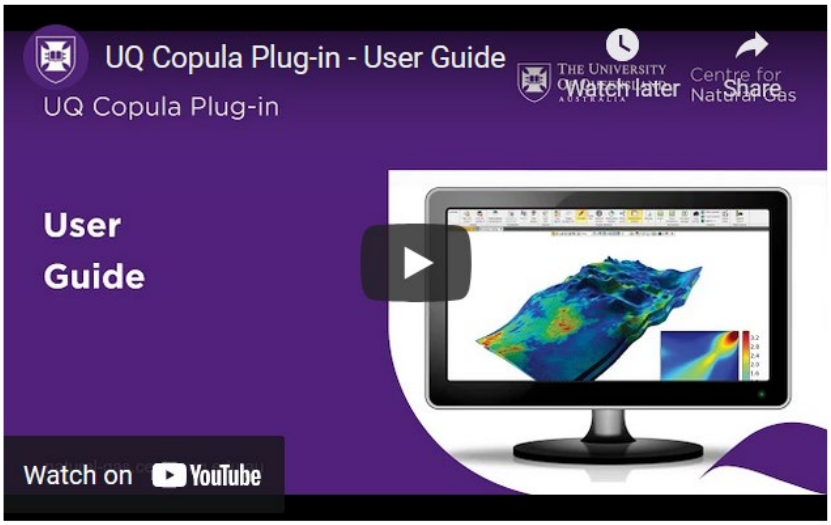
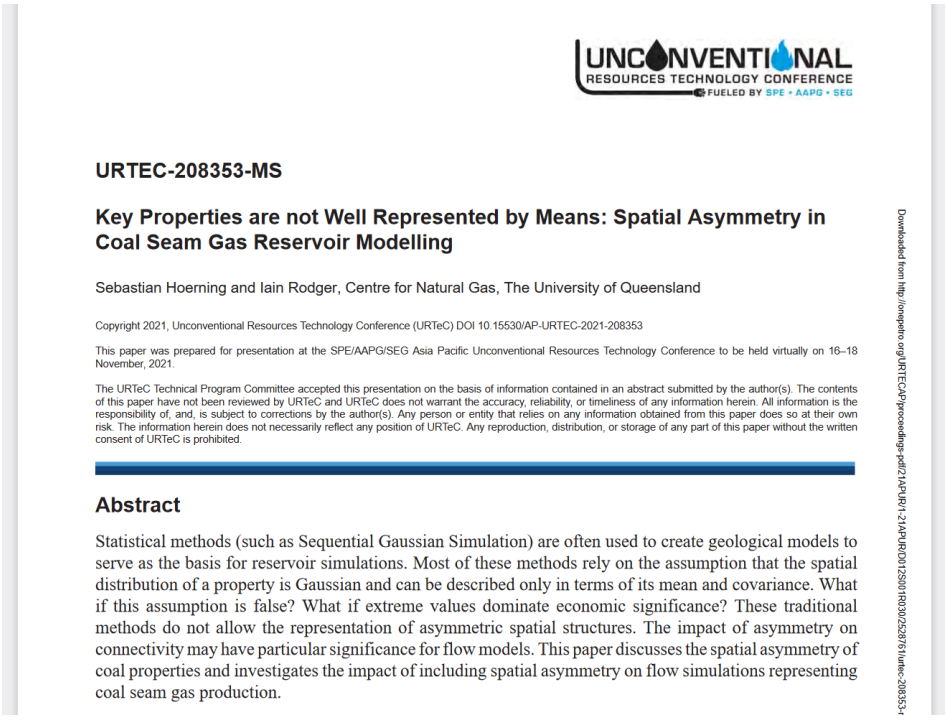
Downloadable booklet	Video user guide
 UQ Copula Plug-in - User Guide (Petrel 2017-2019)	

Figure 6: Plug-in user guide and video

The Stage 1 and Stage 2 reports have been distributed during the course of the project but can be made available again if requested. The paper 'Key Properties are not Well Represented by Means: Spatial Asymmetry in Coal Seam Gas Reservoir Modelling' has been presented at the SPE/AAPG/SEG Asia Pacific Unconventional Resources Technology Conference, Virtual, November 2021 (Fig. 7). It shows an application of the plug-in to a real-world data set and can be found here: https://doi.org/10.15530/AP-URTEC-2021-208353



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Key Properties are not Well Represented by Means: Spatial Asymmetry in Coal Seam Gas Reservoir Modelling

Sebastian Hoerning and Iain Rodger, Centre for Natural Gas, The University of Queensland

Abstract

Statistical methods (such as Sequential Gaussian Simulation) are often used to create geological models to serve as the basis for reservoir simulations. Most of these methods rely on the assumption that the spatial distribution of a property is Gaussian and can be described only in terms of its mean and covariance. What if this assumption is false? What if extreme values dominate economic significance? These traditional methods do not allow the representation of asymmetric spatial structures. The impact of asymmetry on connectivity may have particular significance for flow models. This paper discusses the spatial asymmetry of coal properties and investigates the impact of including spatial asymmetry on flow simulations representing coal seam gas production.

Figure 7: URTec paper

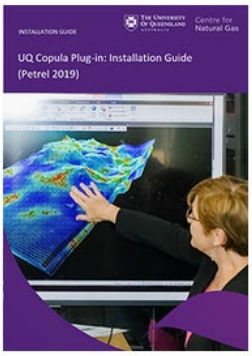
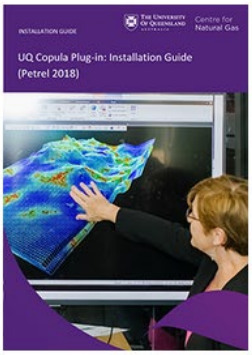
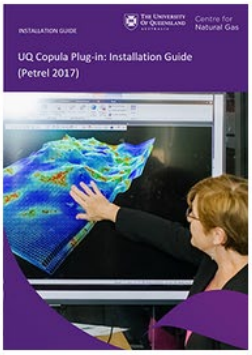
Downloadable booklets	Video installation guide
 UQ Copula Plug-in - Installation Guide (Petrel 2019)  UQ Copula Plug-in - Installation Guide (Petrel 2018)  UQ Copula Plug-in - Installation Guide (Petrel 2017)	

Figure 7: Plug-in installation guides and video

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