USER GUIDE

THE UNIVERSITY OF QUEENSLAND
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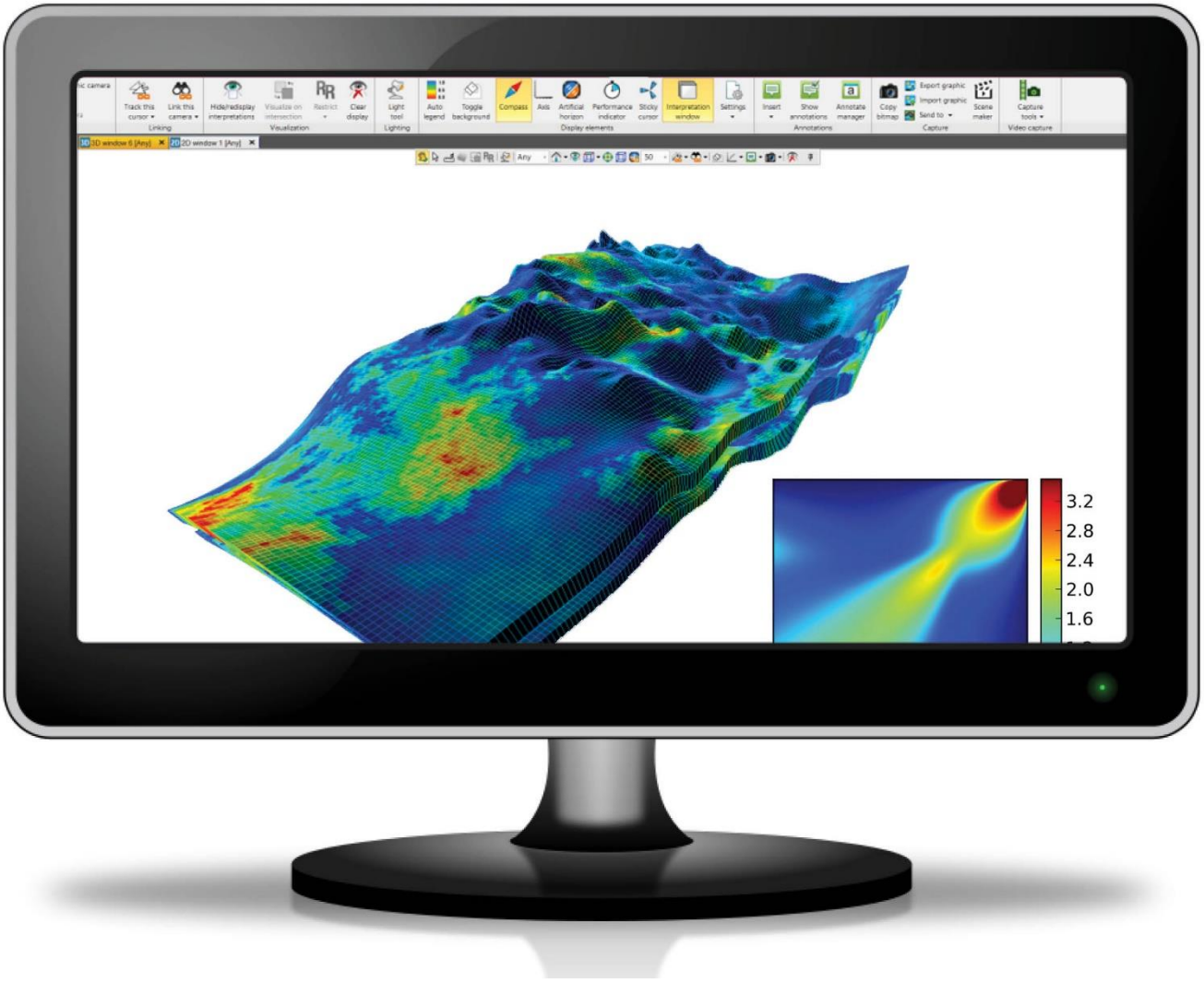
Centre for Natural Gas

UQ Copula Plug-in: User Guide (Petrel 2017-2019)



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Acknowledgements

The UQ Copula Plug-in for Petrel is an initiative of The University of Queensland Centre for Natural Gas. The plug-in makes new "research code" developed by the UQ Centre for Natural Gas more broadly available for use by industry professionals, by integrating it with widely-used modelling package, Petrel.

The plug-in for Petrel and this user guide was prepared for The University of Queensland Centre for Natural Gas by Petrotechnical Data Systems. Lead researcher for the project, Dr Sebastian Hörning from the UQ Centre for Natural Gas, provided additional material and support.

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Disclosure

The UQ Centre for Natural Gas is currently funded by the University of Queensland and the Industry members (Arrow Energy, APLNG and Santos). The Centre conducts research across Water, Geoscience, Petroleum Engineering and Social Performance themes.

For more information about the Centre's activities and governance see natural-gas.centre.uq.edu.au

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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.

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1 Document Overview

This document describes how to use the UQ Copula Plug-in, in the Petrel® 2017/18/19 E&P software platform. The UQ Copula Plug-in is used to generate conditional random fields. After analysing the input data, a theoretical copula model is fitted to the data using a maximum likelihood approach. A sequential copula-based simulation approach is subsequently used to generate conditional realisations

1.1 System Requirements

Users are required to have Petrel 2017/8/9.x installed to run the UQ product. Please be advised that the Petrel platform only runs on Microsoft Windows operating systems (Windows 7 or higher).

1.2 Installation

If the UQ Copula Plug-in is unavailable, then please revert to the Installation guide to ensure that the plug-in is available in Petrel.

There is also an accompanying installation video available.

2 Background

Copulas are multivariate distribution functions (Nelson, 1999) defined on the unit hypercube with all univariate marginals being uniformly distributed on [0, 1]. They are used to describe the dependence between random variables independently of their marginal distributions, that is, monotonic transformations of the marginals do not influence the dependence structure. Copulas are linked to multivariate distributions by Sklar's theorem (Sklar, 1959) that proves that any continuous multivariate distribution can be represented with the help of a unique copula.

In the geostatistical context, spatial copulas can be used to describe the joint multivariate distribution corresponding to variables that are spatially distributed in the domain of interest (Bárdossy, 2006) where the spatial configuration of the data points is considered via a correlation matrix. Here two different copula models, the Gaussian copula and the v-transformed normal copula are available. The v-transformed normal copula allows the user to go beyond Gaussian spatial dependence structures and enables modelling of asymmetric spatial random fields (Bárdossy and Li, 2008; Guthke, 2013). After a spatial data analysis, a maximum likelihood approach based on disjoint subsets of the input data is used to fit a theoretical spatial copula model to the available data. This fitted model is subsequently used in a sequential copula-based simulation approach to generate conditional spatial random fields (Li, 2010).

3 Modes of operation

There are four alternatives approaches to using the UQ Copula Plug-in:

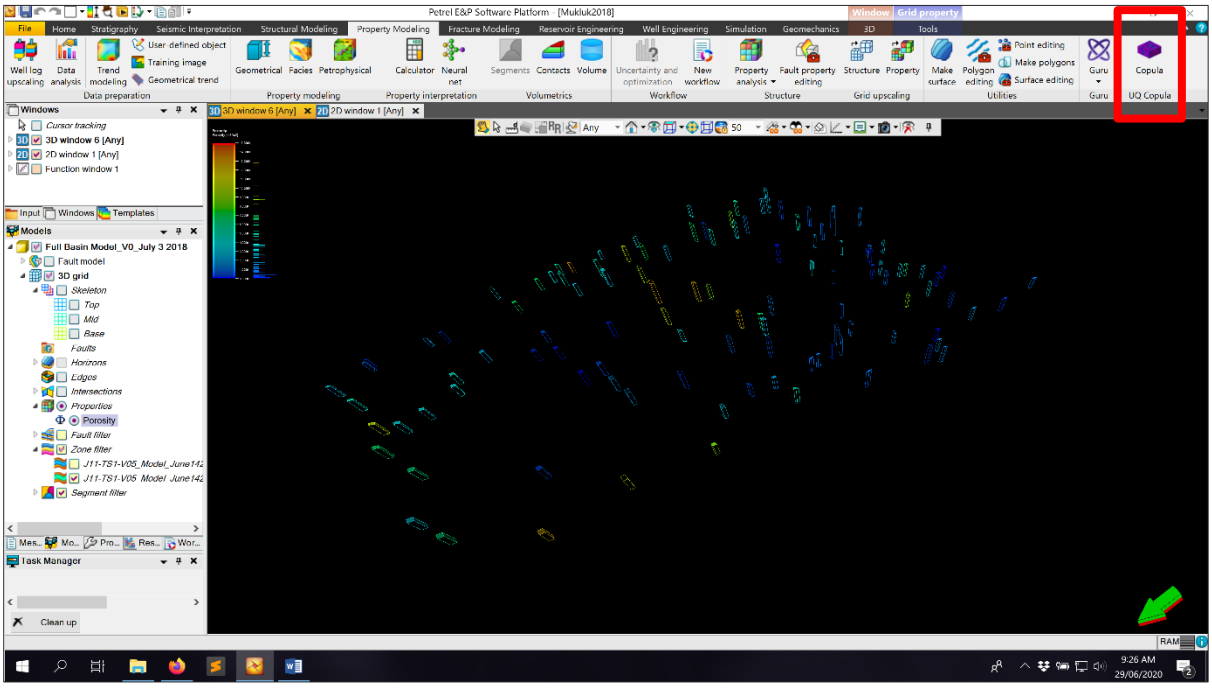
1. Standalone mode
2. Within Petrophysical modelling
3. Workflow manager – Standalone
4. Workflow manager – Within Petrophysical modelling

The remainder of this document with explain how to use the four alternative plug-in modes.

These modes are also demonstrated in the accompanying user guide video.

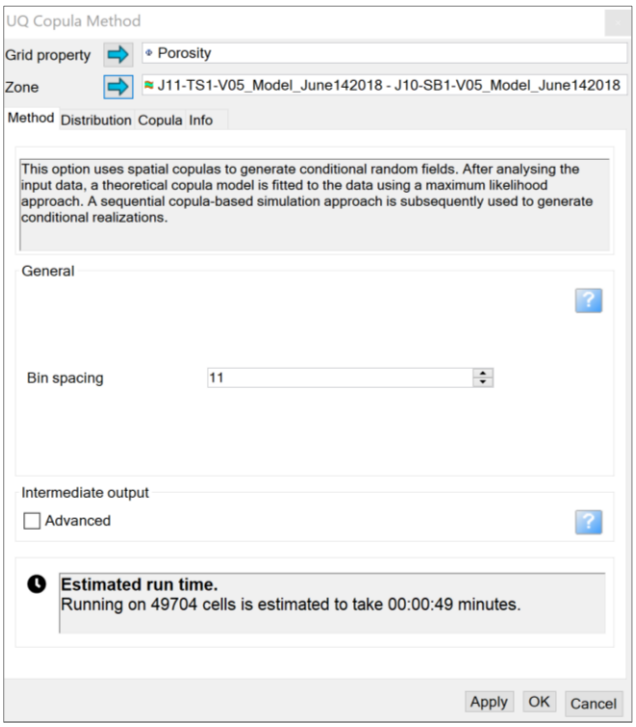
3.1 Operation in standalone mode

The standalone version of the plug-in can be launched from the *property modelling ribbon*. Click the icon to launch the plug-in dialogue.



The user interface comprises an input area plus four tabs:

1. Method (Select between *default* and *expert* settings)
2. Distribution (Expert settings – Part 1)
3. Copula (Expert settings – Part 2)
4. Info (General information)



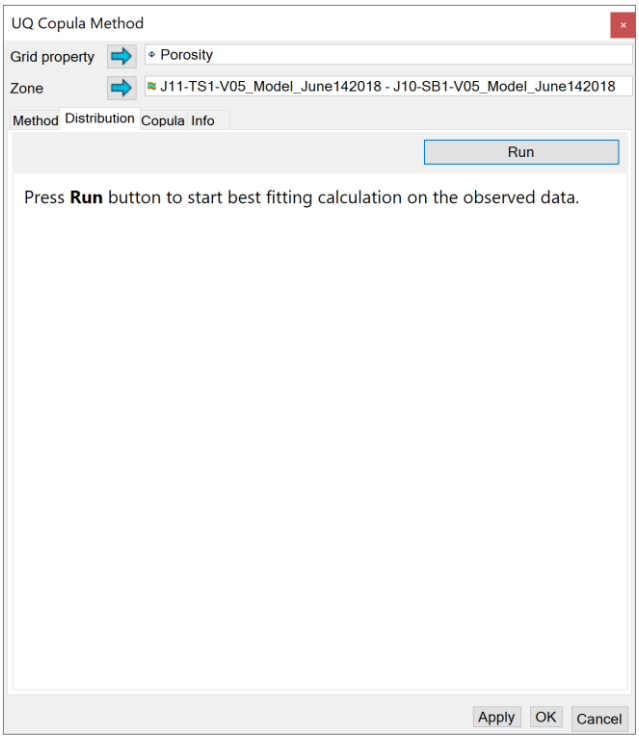
In order to proceed two inputs are required:

1. An upscaled grid property (e.g. permeability)
2. Model zone (selected from the 3D grid)

Once these inputs are provided the estimated run time is calculated and displayed in the interface.

It is possible to select *apply* or *OK* to run the algorithm. Alternatively, the bin spacing can be adjusted.

It is also possible to access the expert setting by selecting the *advanced checkbox* in the *method tab*. This will activate firstly the **distribution** and then the *copula tabs*.



After starting the copula function in Petrel an interactive GUI pops up which allows the user to fit the marginal distribution.

The histogram represents the data and the red function is the fitted probability density function (pdf). It automatically generates an initial 'best' fit based on the input data.

If the user is not happy with the fit, the pdf can be changed using the sliders, which represent the distribution parameters.

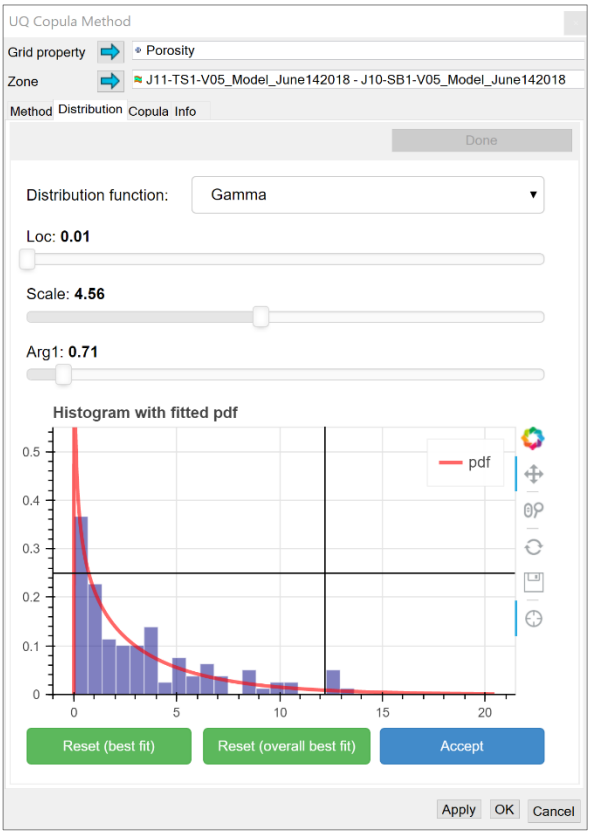
The user can also choose a different type of distribution function, which can again be changed using the sliders.

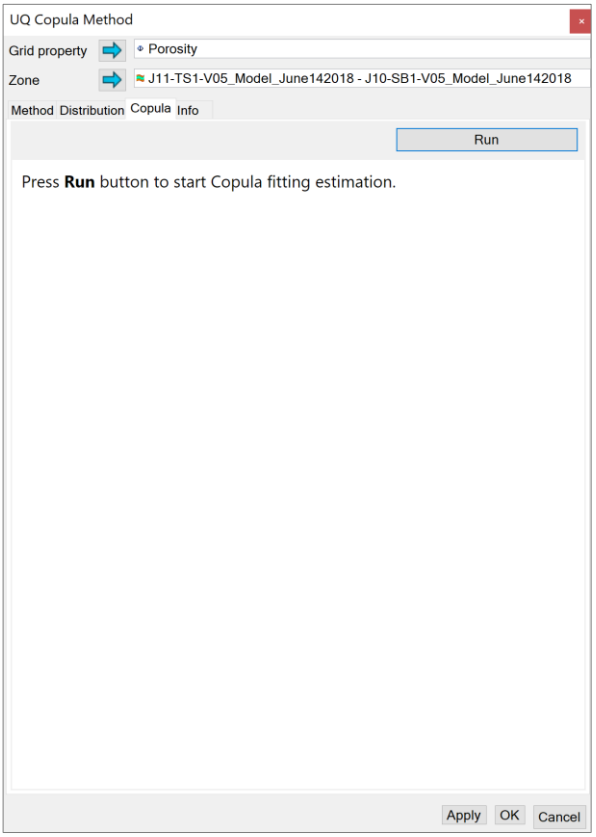
If there is not enough data available to fit a meaningful distribution, then the user is free to specify any of the available distributions.

There are options to reset to the initial best fit and the best fit for the currently selected distribution function.

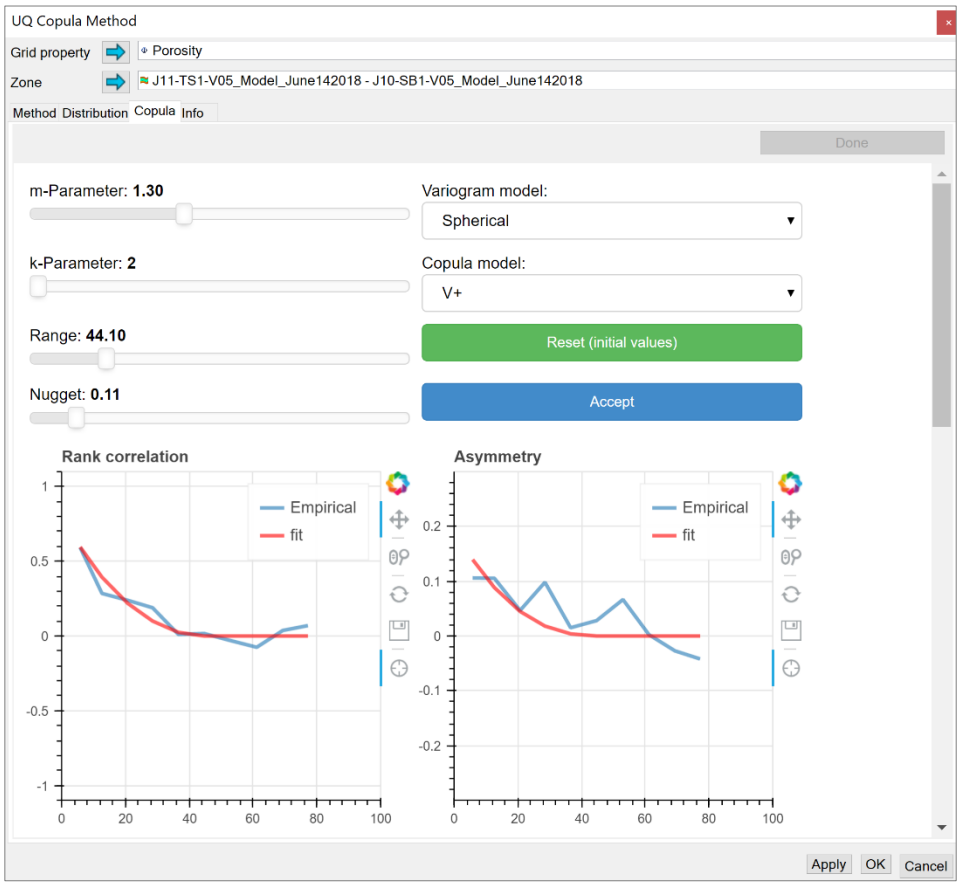
Once ready to proceed, *click accept* to activate the *copula tab*.

Press run to generate the Copulas.



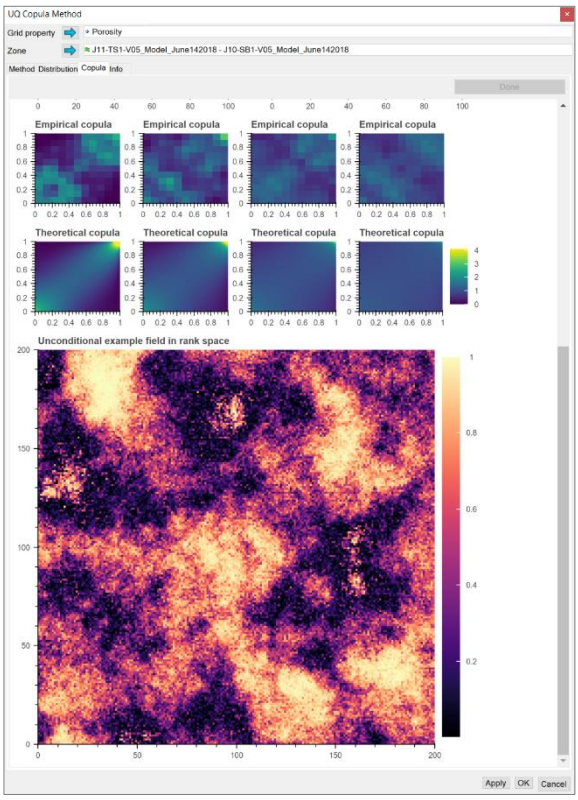


After the fitting process another GUI pops up (with the initial 'best' fit) which allows the user to change the fit of the copula.



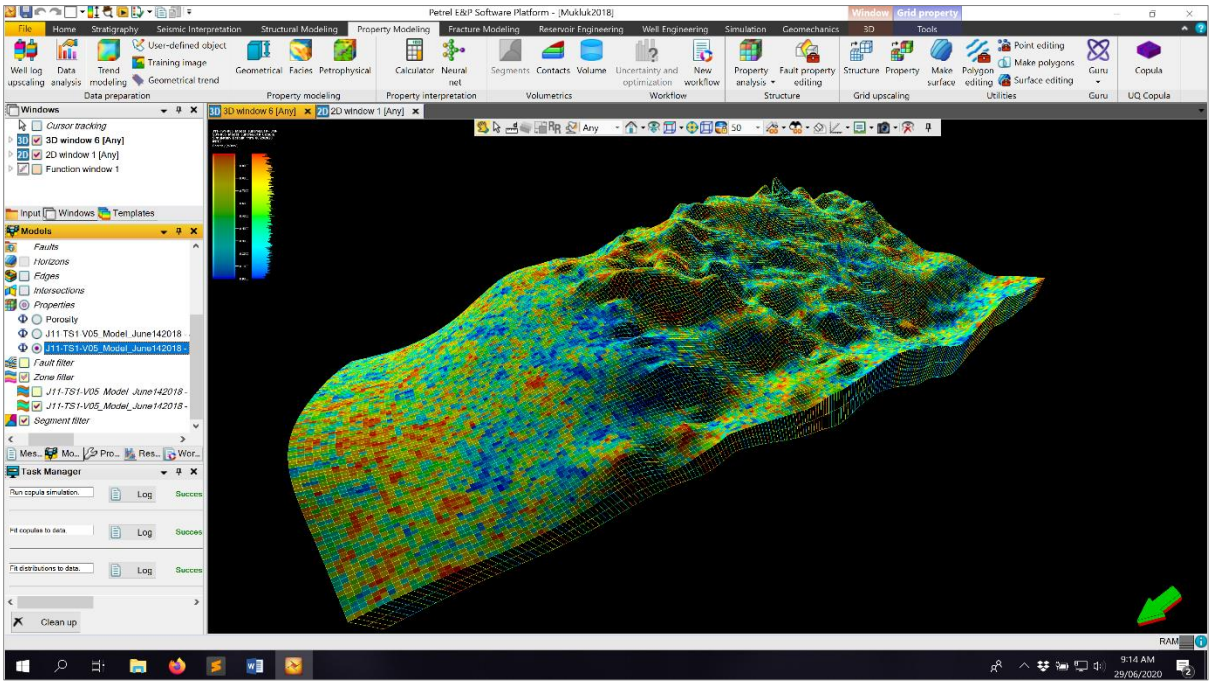
The different copula parameters can be changed using the sliders and selection boxes and the corresponding theoretical copulas are interactively updated. The theoretical rank correlation function and the asymmetry function are also updated. Thus the user can try to achieve a better fit to the empirical functions/copulas.

Additionally, an unconditional spatial random field using the current parameters is displayed. This gives the user an idea of the spatial structures that would result from the current set of parameters (this is pretty handy as it is rather difficult to guess what a field using different copula parameters would look like).



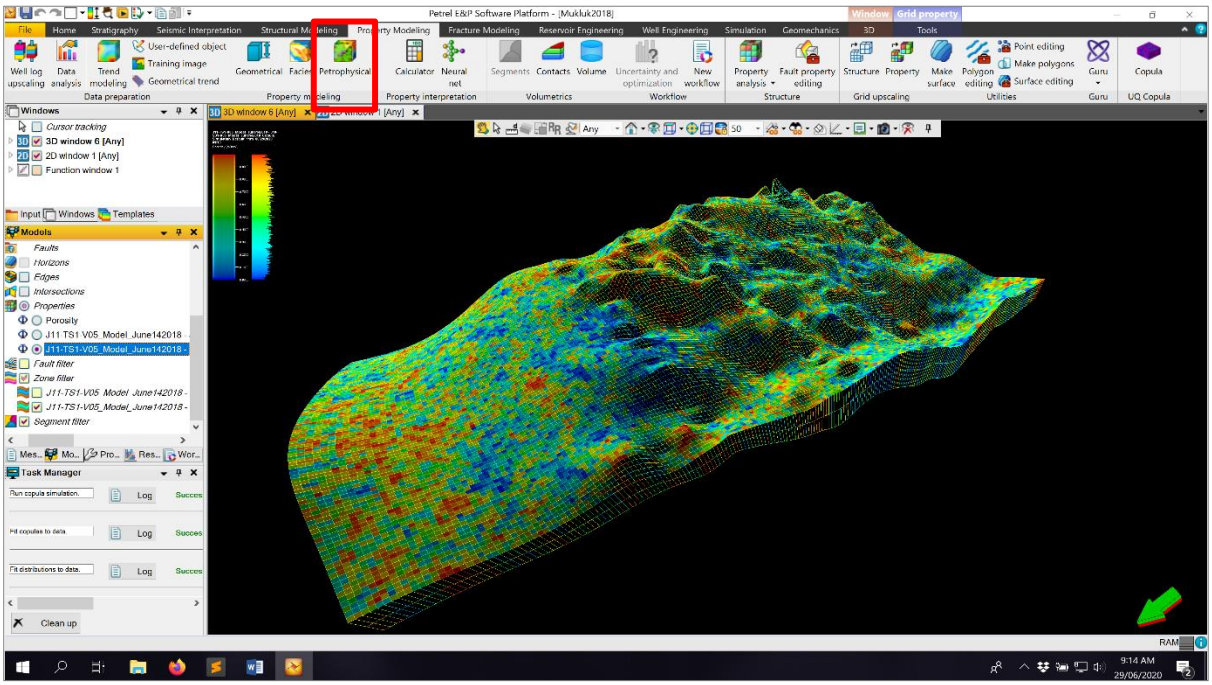
There is an option to reset to the initial best fit and the save button closes the GUI and returns the current set of parameters to Petrel for the subsequent simulation or (in the new version) interpolation.

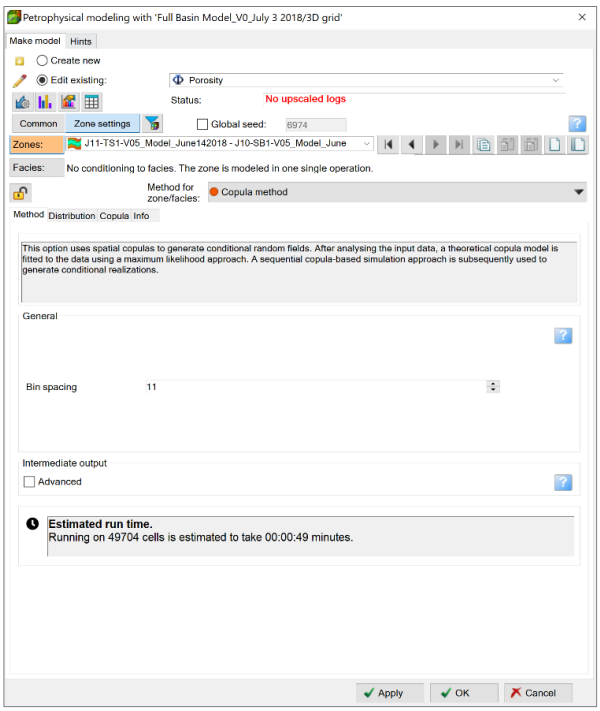
Two properties are generated, one representing the field and the second the output petrophysical property. Outputs are presented within the Properties part of the 3D grid, in the Models pane. Also, the progress of the algorithm is shown in the Task Manager.

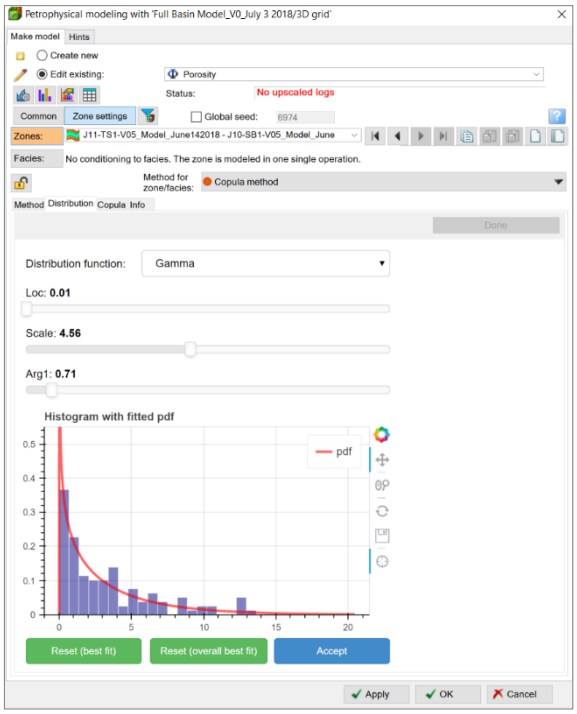


3.2 Operation in petrophysical modelling

The UQ Copula method can also be accessed through the Petrophysical modelling process. It operates in the same manner as the standalone process.

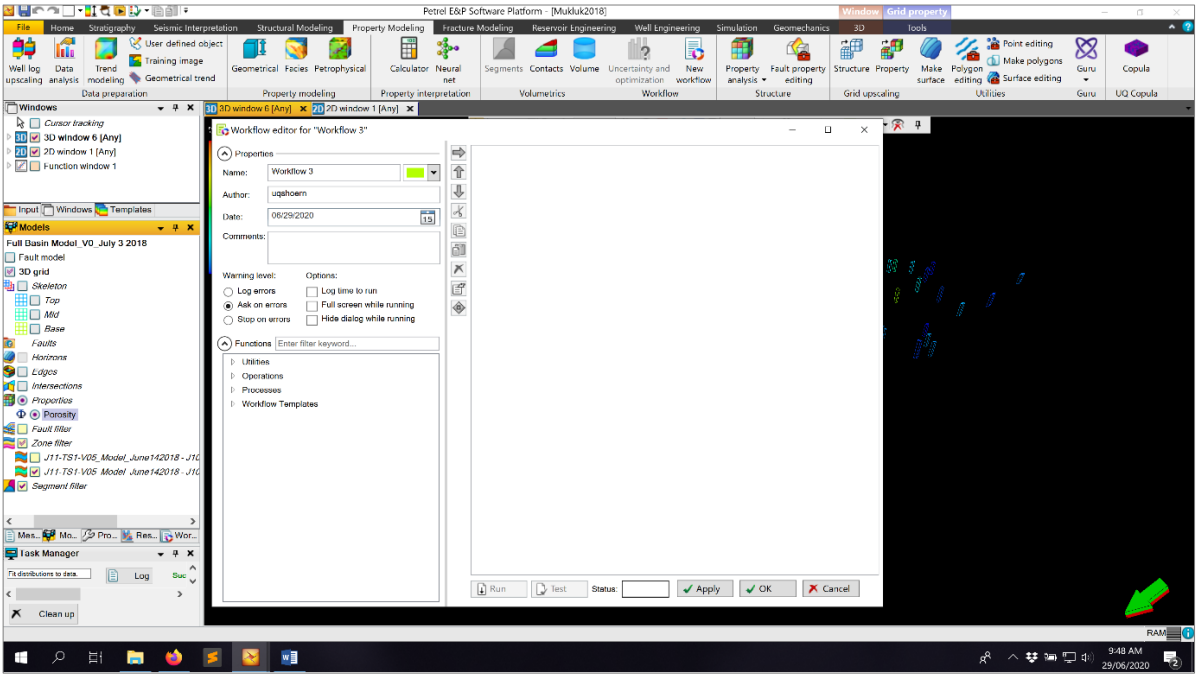


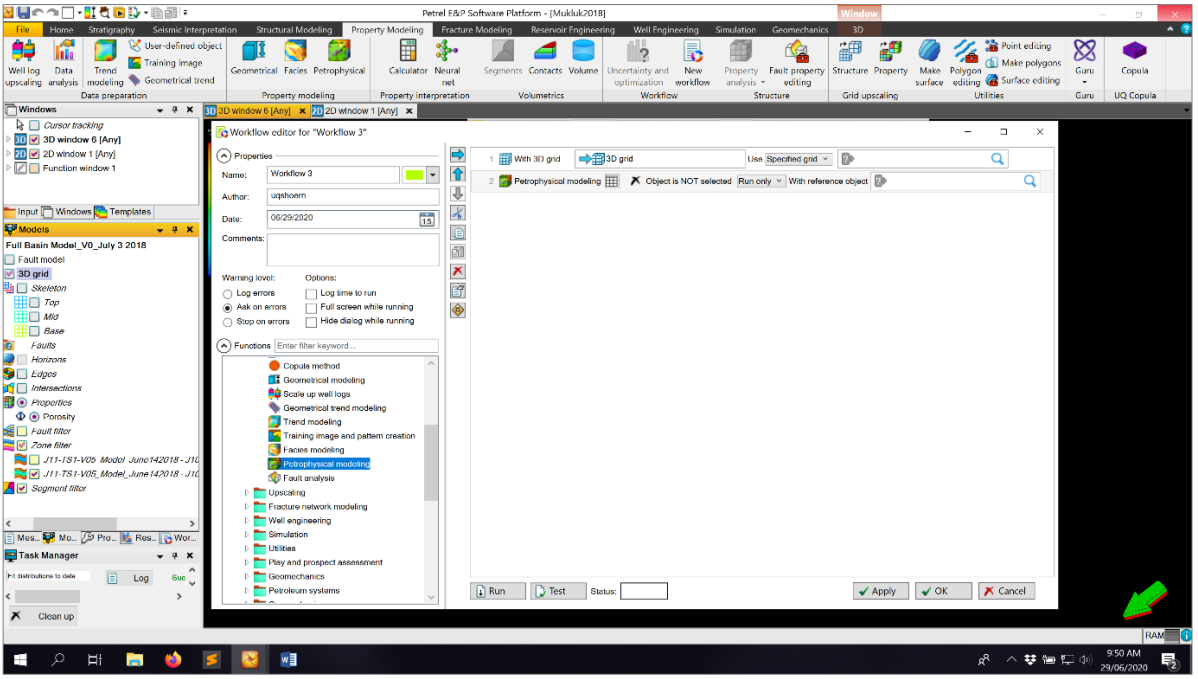




3.3 Operation in the workflow manager

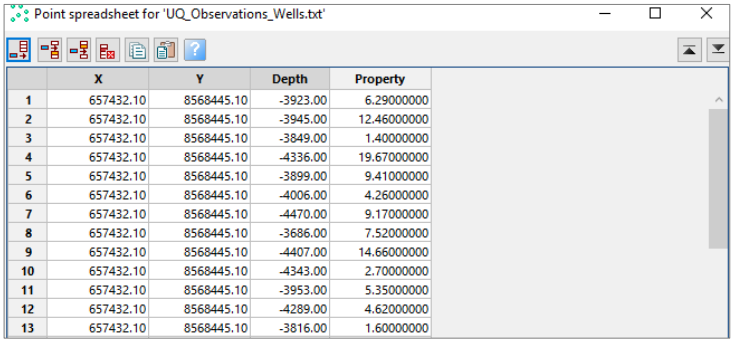
It is possible to use the UQ Copula method in both the standalone mode and via petrophysical modelling. The following screenshots highlight the location of the relevant processes. Note that Advanced mode is not available in the processes via the workflow manager.



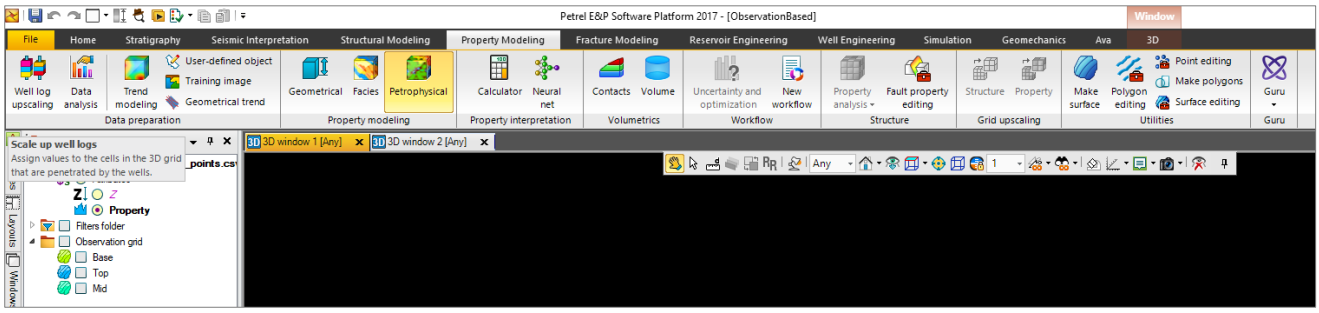


Aside: Converting observation point sets into upscaled cells

The points can be scaled up to become the property for the Petrel 3D Grid. Petrel grids can be easily created. Simple grid creation and Upscaling can be done using the corresponding Petrel tools, which are located in the Petrel Structural Modelling and Property Modelling ribbons.



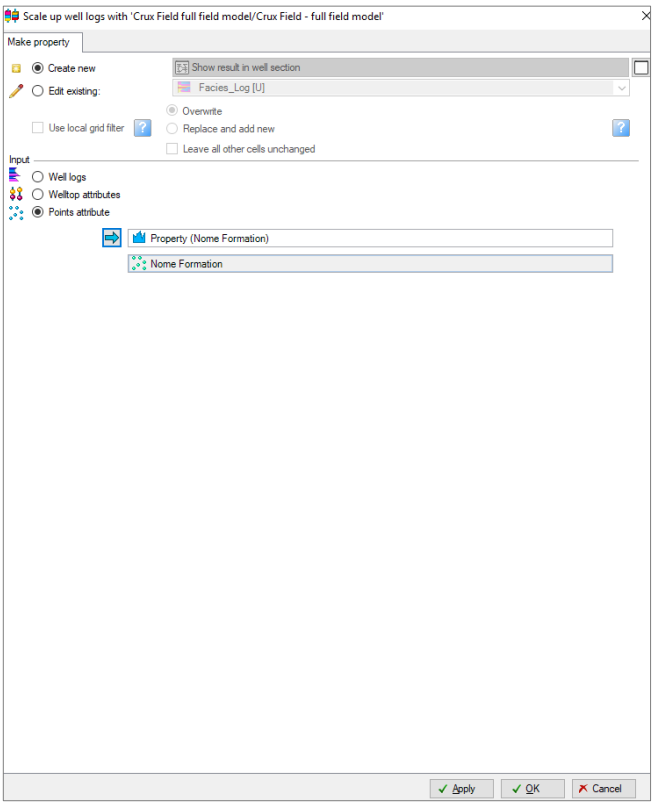
	X	Y	Depth	Property
1	657432.10	8568445.10	-3923.00	6.29000000
2	657432.10	8568445.10	-3945.00	12.46000000
3	657432.10	8568445.10	-3849.00	1.40000000
4	657432.10	8568445.10	-4336.00	19.67000000
5	657432.10	8568445.10	-3899.00	9.41000000
6	657432.10	8568445.10	-4006.00	4.26000000
7	657432.10	8568445.10	-4470.00	9.17000000
8	657432.10	8568445.10	-3686.00	7.52000000
9	657432.10	8568445.10	-4407.00	14.66000000
10	657432.10	8568445.10	-4343.00	2.70000000
11	657432.10	8568445.10	-3953.00	5.35000000
12	657432.10	8568445.10	-4289.00	4.62000000
13	657432.10	8568445.10	-3816.00	1.60000000



Here an example of the Scale up dialog, where points attributes are scaled up to create a property that is going to be used for the Spatial Copulas Property Modelling.

After pressing the Apply or OK button the resulting upscaled point property is ready to be used as input for the Petrel Petrophysical modelling dialogue.

The Spatial Copulas plugin will use the "Edit the property" option to generate the modelling output. Select the input property from the input data. These upscaled cells will be used as input to the modelling, next you have to select the model zones that will be included in the calculation. Note that it can be applied to a set of zone in the 3D grid. Define the settings for each zone in a set of sub-menus.



4 References

Nelsen R (1999), An introduction to copulas, *Springer Verlag*, New York.

Sklar A (1959), Fonctions de répartition à n dimensions et leurs marges, *Publ. Inst. Stat*. Paris, 8, 229–131.

Bárdossy A (2006), Copula-based geostatistical models for groundwater quality parameters, *Water Resources Research*, 42(W11416), doi:10.1029/2005WR004,754.

Bárdossy A & Li J (2008), Geostatistical interpolation using copulas, *Water Resources Research*, 44(W07412), doi:10.1029/2007WR006115.

Guthke P (2013), Non-multi Gaussian spatial structures: Process-driven natural genesis, manifestation, modeling approaches, and influences on dependent processes., Eigenverlag des Instituts Wasserbau.

Li J (2010), *Application of Copulas as a New Geostatistical Tool*, Eigenverlag des Instituts Wasserbau.

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