

# New features of otgui 2018

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OpenTURNS users day #11, Saclay, France



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otgui overview

FMI models

Advanced visualization

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## otgui summary

- ▶ Generic "OpenTURNS" gui
- ▶ Aims at exposing uncertainty methods to non-experts
- ▶ Partnership EDF-Phimeca
- ▶ Distributed since 2016 at EDF through Salome



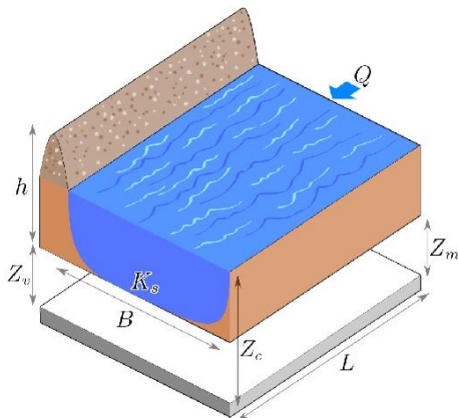
# otgui methods

- ▶ Data analysis (moments, visualisation, inference)
- ▶ Probabilistic modeling (continuous marginals, copulas)
- ▶ Meta modeling (chaos, kriging), Optimization
- ▶ Sensitivity analysis (Sobol', SRC, Morris)
- ▶ Reliability (Taylor, Monte Carlo, FORM, SORM, FORM-IS)

## study example 1/13: math model

The flood model of a river compares the water level to the dike height:

$$S = \left( \frac{Q}{K_s \times 300 \times \sqrt{(Z_m - Z_v)/5000}} \right)^{3/5} + Z_v - 55.5 - 3$$



## study example 2/13: physical model definition

OTGui - [Symbolic physical model]

File View Help

Studies

- myStudy
  - Physical models
    - myPhysicalModel
      - Definition
        - Probabilistic model
        - Reliability
          - limitState1
            - myMonteCarlo
            - myformIS

Definition Differentiation

Inputs

Name	Description	Value
1 Q	Débit maximal annuel (m3/s)	1000
2 Ks	Strickler (m <sup>4</sup> /1/3/s)	30
3 Zv	Côte de la rivière en aval (m)	50
4 Zm	Côte de la rivière en amont (m)	55

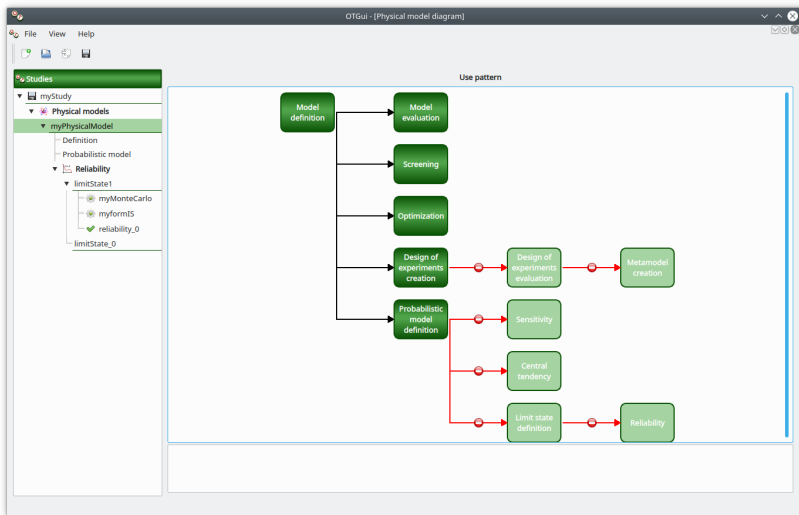
+ Add - Remove

Outputs

<input type="checkbox"/> Name	Description	Formula	Value
<input checked="" type="checkbox"/> 1 S	Surverse (m)	$(Q/(Ks*300.*sqrt((Zm-Zv)/5000)))^{(3.0/5.0)+Zv-55.5-3.}$	?

+ Add - Remove Evaluate

## study example 3/13: study diagram



## study example 4/13: math model

Probabilistic model:

- ▶  $Q \sim \text{Gumbel}(\alpha=0.00179, \beta=1013)$ , flow rate [ $m^3 s^{-1}$ ]
- ▶  $K_s \sim \text{Normal}(\mu=30.0, \sigma=7.5)$ , strickler [ $m^{1/3} s^{-1}$ ]
- ▶  $Z_v \sim \text{Uniform}(a=49, b=51)$ , downstream depth [m]
- ▶  $Z_m \sim \text{Uniform}(a=54, b=56)$ , upstream depth [m]



# study definition 5/13: probabilistic model definition

OTGui - [Probabilistic model]

File View Help

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Marginals Dependence

	Variable	Distribution
1	Q	Gumbel
2	Ks	Normal
3	Zv	Uniform
4	Zm	Uniform

Graph setting

Title PDF

☒ PDF ☐ CDF

X-axis Y-axis

Title Q

Min -1661.86909738

PDF

Density

Q

Parameters

Type  $\alpha, \beta$

$\alpha$  0.00179211

$\beta$  1013

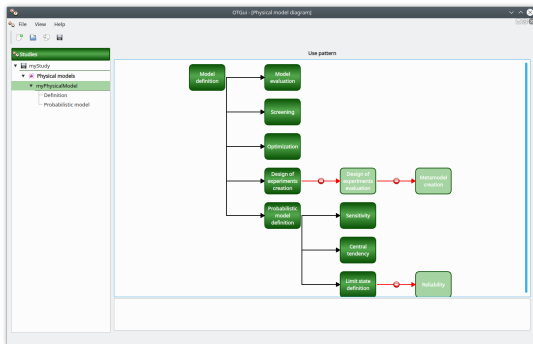
Truncation parameters

☒ Lower bound 0

☐ Upper bound

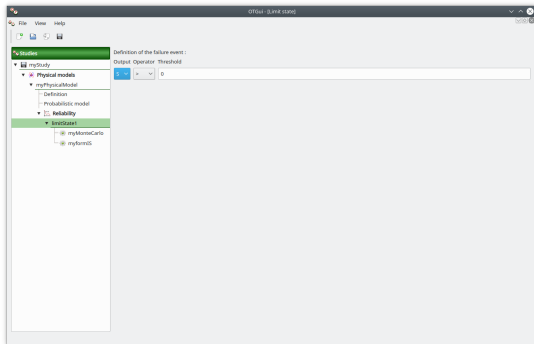
Import Morris result

## study example 6/13: study diagram

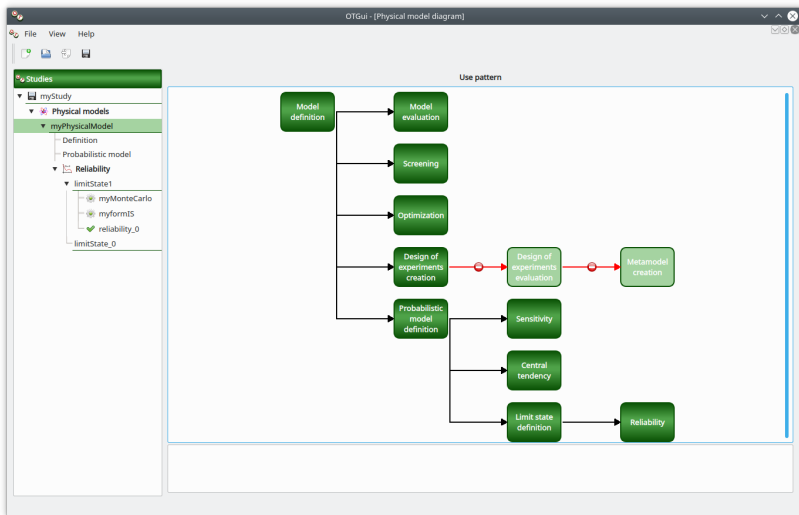


## study example 7/13: limit-state definition

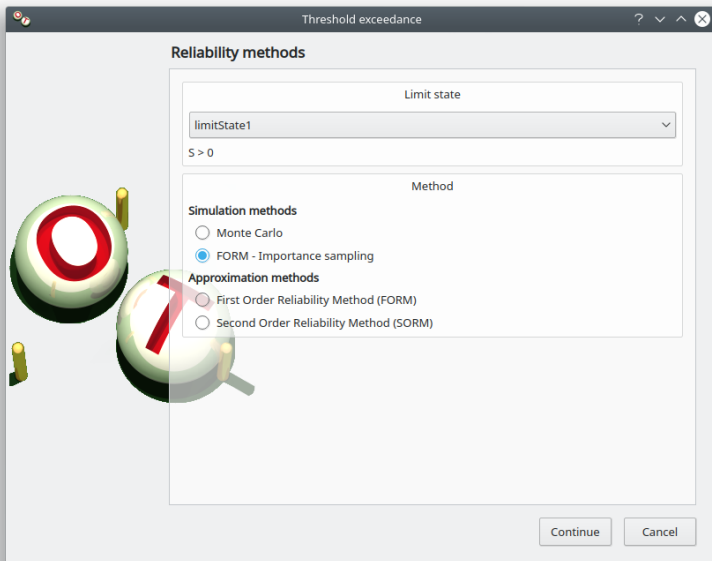
Failure occurs when  $S$  is positive, lets estimate  $P_f = \mathbb{P}(S(\underline{X}) > 0)$ .



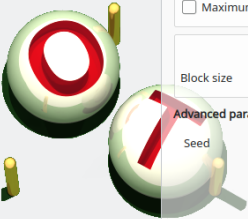
## study example 8/13: study diagram



## study example 9/13: simulation wizard



## study example 10/13: simulation wizard



Threshold exceedance

### Simulation methods

**Stop criteria**

- ☒ Accuracy - coefficient of variation 0.01
- ☒ Maximum time d h 1 m s
- ☐ Maximum calls 10000

**Evaluation parameter**

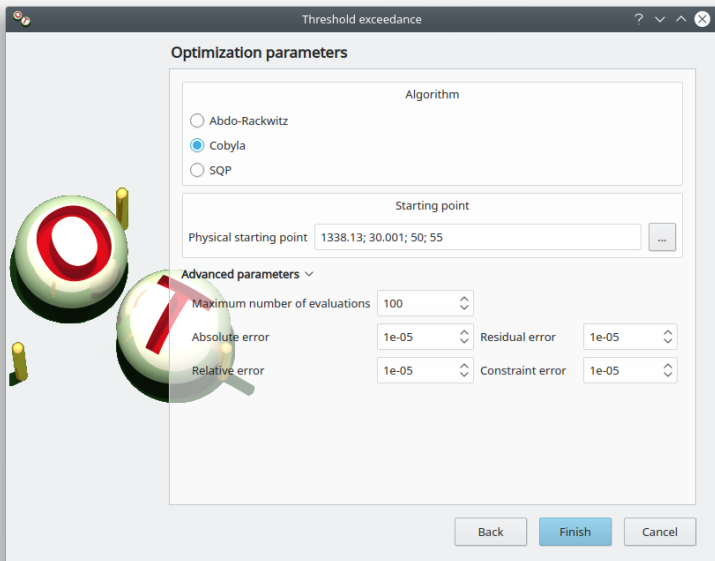
Block size 1

Advanced parameters ▾

Seed 0

Back Continue Cancel

## study example 11/13: simulation wizard



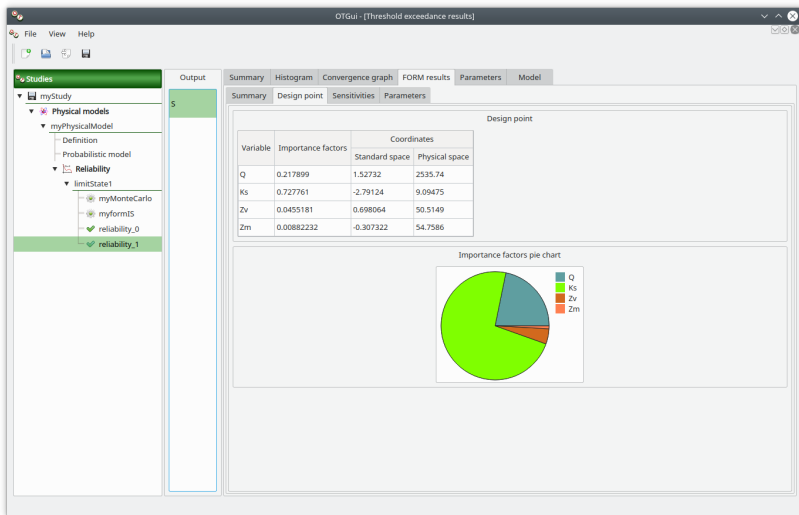
# study example 12/13: simulation result window

The screenshot shows the OTGui interface with the title bar 'OTGui - [Threshold exceedance results]'. The menu bar includes 'File', 'View', and 'Help'. The left sidebar, titled 'Studies', shows a tree structure: 'myStudy' (expanded) contains 'Physical models' (expanded) which contains 'myPhysicalModel' (expanded) which contains 'Definition', 'Probabilistic model', and 'Reliability' (expanded). Under 'Reliability' is 'limitState1' (expanded) which contains 'myMonteCarlo', 'myformIS', 'reliability\_0', and 'reliability\_1' (selected and highlighted in green). The main area has tabs: 'Summary', 'Histogram', 'Convergence graph', 'FORM results', 'Parameters', and 'Model'. The 'Summary' tab is active, showing 'Stop criteria' with 'Elapsed time' (2.714 s) and 'Number of calls' (52780). Below this is the 'Failure probability estimate' section, which contains a table:

Estimate	Value	Confidence interval at 95%	
		Lower bound	Upper bound
Failure probability	0.000650797	0.000638042	0.000663552
Coefficient of variation	0.00999946		



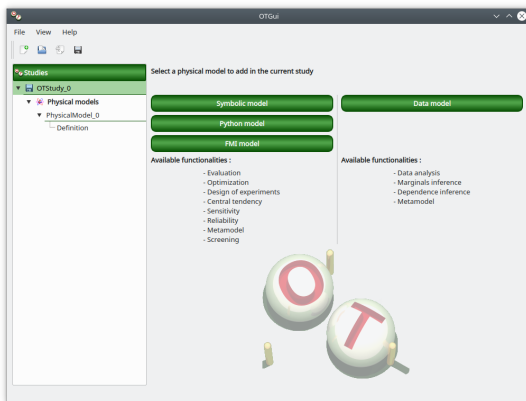
# study example 13/13: simulation result window



# FMI models

Different types of models already available:

- ▶ Symbolic
- ▶ Python
- ▶ YACS (Salome execution engine)



# FMI models

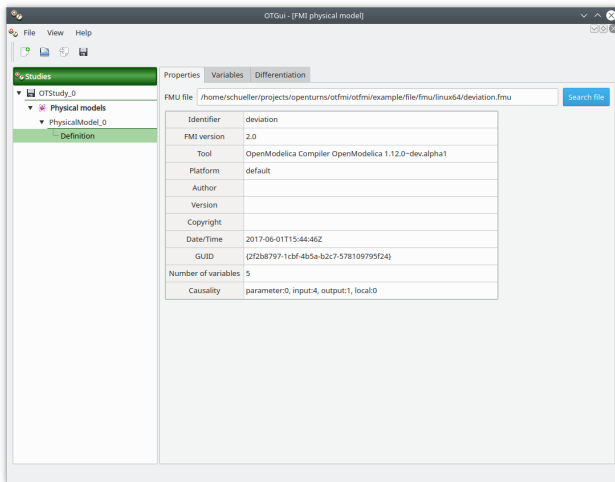
New model type:

- ▶ Evaluate system models in the FMI standard
- ▶ Open FMU binaries from Modelica simulation IDEs (OpenModelica, Dymola, ...)



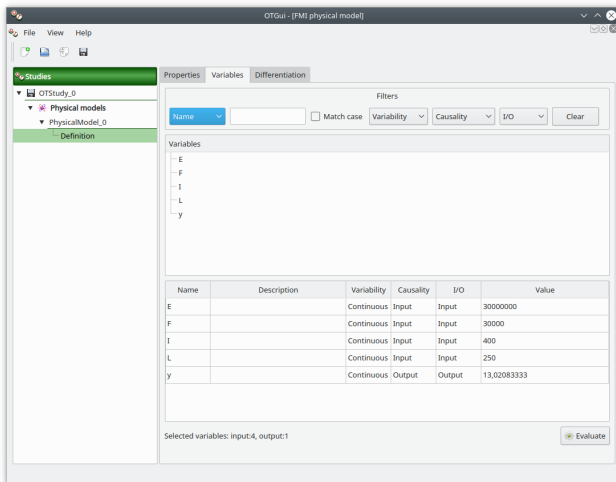
# FMI models

Inspect model properties (tools, author, version, ...)



# FMI models

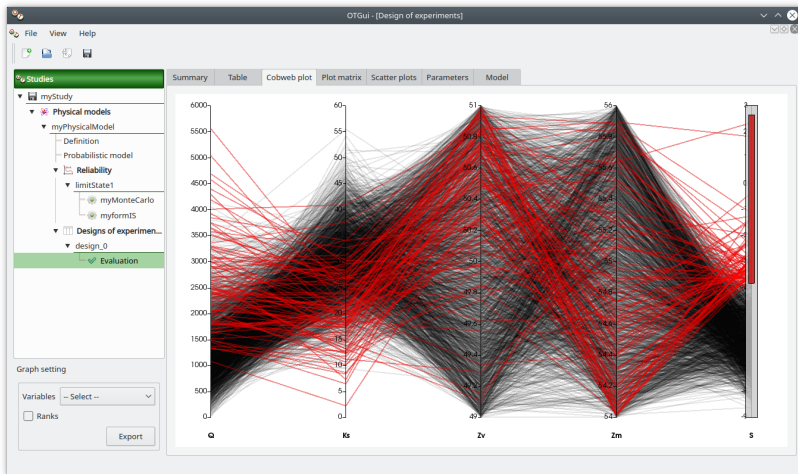
Inspect model variables (type, causality, ...), select inputs/outputs



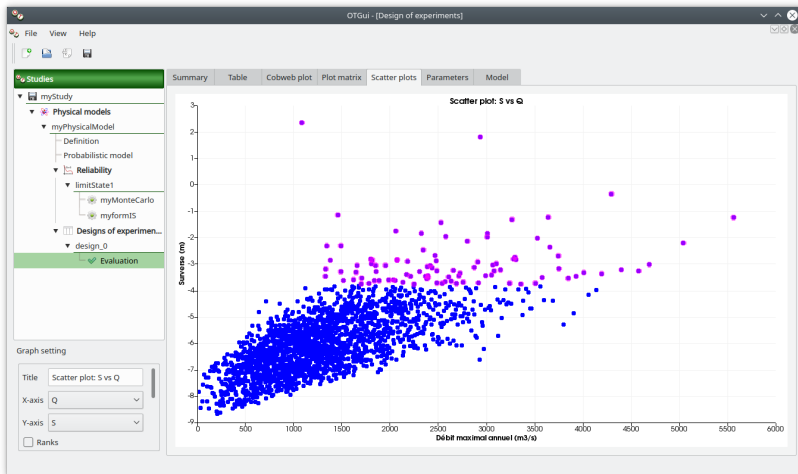
# Advanced visualization

- ▶ Using Paraview graphics library
- ▶ Interactive widgets
- ▶ Model/view paradigm: several views on the same data
- ▶ Help visualize DOEs (Monte Carlo simulation, outliers, ...)

# Cobweb plots

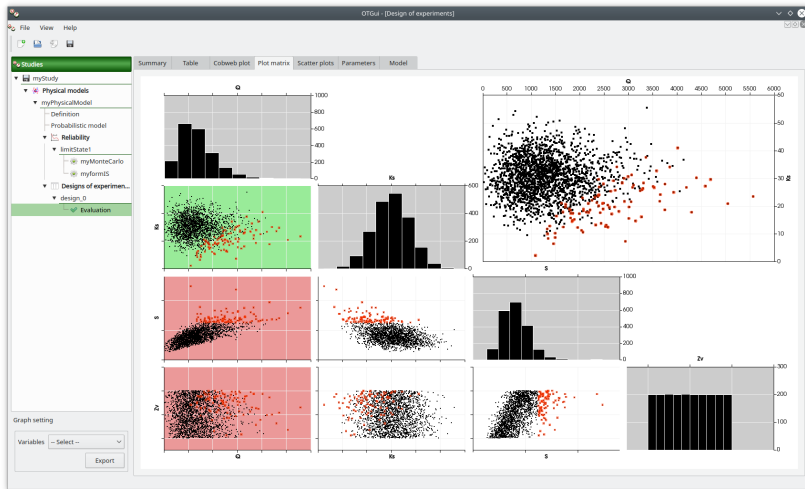


# Scatter plots





## Matrix plot



## Table

OTGui - [Design of experiments]

File View Help

Studies

- myStudy
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      - Probabilistic model
      - Reliability
        - limitState1
          - myMonteCarlo
          - myformIS
      - Designs of experimen...
        - design\_0
          - Evaluation

Summary Table Cobweb plot Plot matrix Scatter plots Parameters Model

Size : 2000

Row ID	Ks	Q	S	Zm	Zv
1804	1804	35.5273	1073.6	-6.17885	54.0207
1805	1805	29.4658	2340.62	-4.27899	55.8278
1806	1806	41.6075	1958.61	-5.34902	54.4961
1807	1807	32.7166	1374.9	-5.88981	54.718
1808	1808	17.5819	2411.49	-3.06509	55.5186
1809	1809	23.6902	1393.21	-4.77093	55.6682
1810	1810	31.9609	2328.99	-5.59052	54.005
1811	1811	20.8787	1523.96	-4.34275	55.8122
1812	1812	31.0865	1166.96	-5.25891	55.4425
1813	1813	39.1037	1987.84	-6.37966	54.8386
1814	1814	34.1604	1392.97	-6.08958	55.2322
1815	1815	29.5445	4681.62	-3.02946	55.0819
1816	1816	13.7439	2428.7	-3.15087	55.6477
1817	1817	21.9185	1359.47	-6.1438	55.1043
1818	1818	29.1782	872.762	-5.50073	54.2284
1819	1819	30.1298	1940.46	-5.5821	54.3833
1820	1820	37.5309	1356.94	-7.34952	55.156
1821	1821	26.942	784.677	-6.41858	55.1274

# Dependency treatment

- ▶ Only Normal copula was available (Spearman)
- ▶ Now all parametric copulas available
- ▶ Copula inference

# Copula inference 1/5: data import

OTGui - [Data model definition]

File View Help

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- myStudy
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        - limitState1
          - myMonteCarlo
            - myformIS
            - reliability\_0
            - reliability\_1
- Data models
  - dataModel\_0
    - Definition

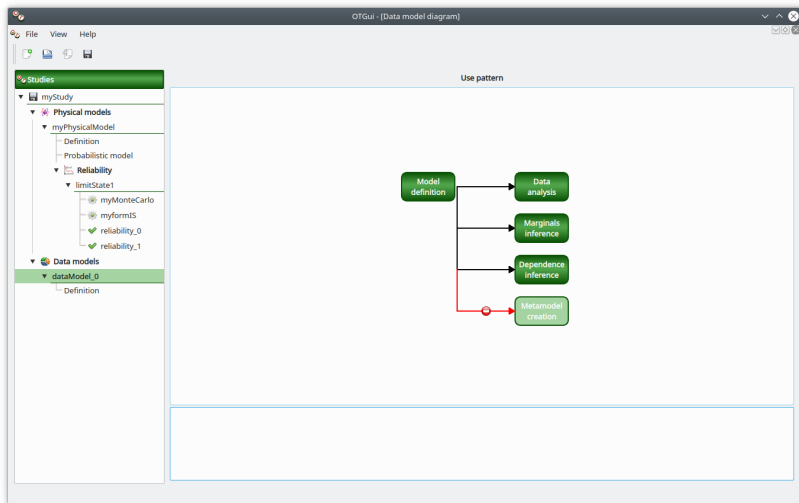
Data file: /tmp/data.csv

Sample

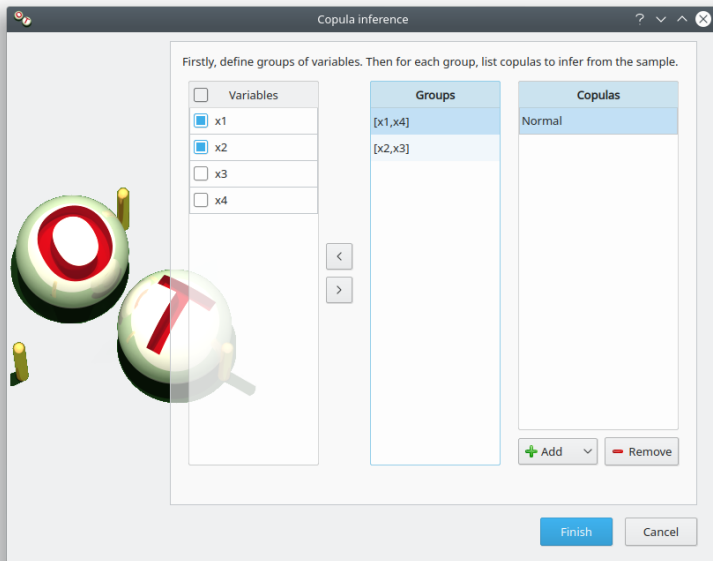
Size: 10000

Name	1	2	3	4
Type	Input	Input	Input	Input
472	5.0001791082	-40.66053082...	187.861164455	0.997079455...
2618	5.00019586861	-34.18000349...	176.910206697	0.30949212296
7344	5.00025448156	-43.26580266...	134.666970314	0.007372048...
5614	5.00026181045	-38.69968601...	162.871228826	0.734886116...
3878	5.00028821953	-37.36464169...	238.140416831	-0.720677830...
8188	5.00035506474	-37.60607161	180.529853663	-0.441404644...
9225	5.00046895591	-31.87110619...	244.28737047	0.937163658...
7314	5.00048978096	-42.89190974...	136.784436688	-0.885816071...
2426	5.00049140008	-37.96392634...	263.268848598	0.999255650...
7296	5.00095557351	-33.65552453...	237.383374783	0.213585904...
9911	5.00100080612	-42.57781669...	137.013176895	0.716510280...
3120	5.00122229013	-44.68645353...	122.682483576	0.333409110...
9413	5.00135062458	-41.09195651...	191.130441094	0.643251147...
3894	5.00148729901	-34.17918821...	214.015458496	-0.416583050...
3515	5.00152238409	-41.340522925	176.665666183	-0.827863148...

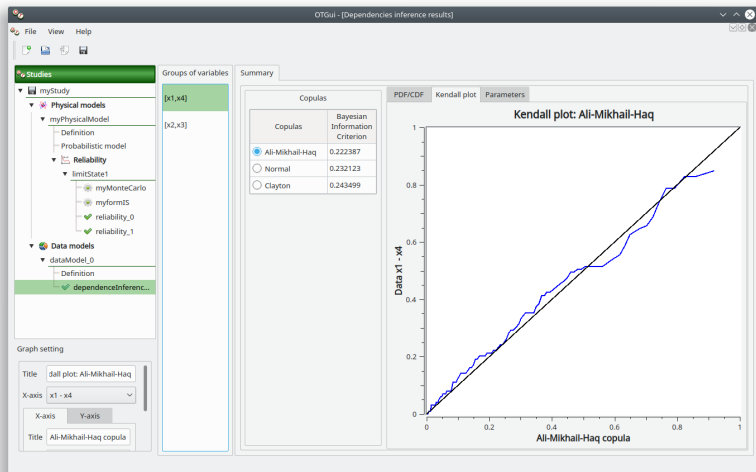
# Copula inference 2/5: study diagram



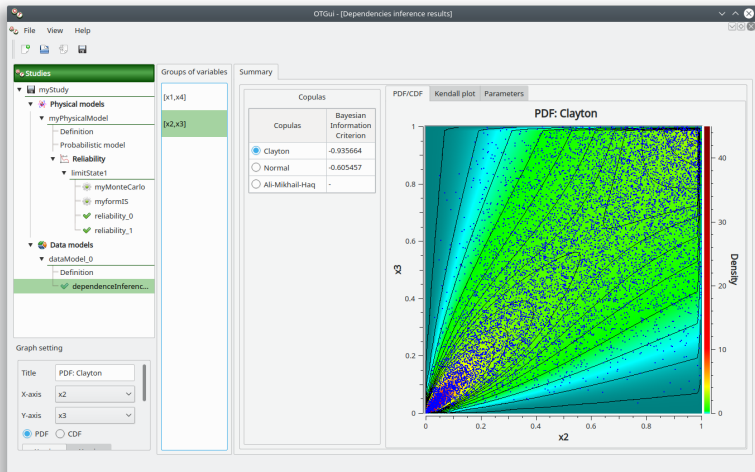
# Copula inference 3/5: dependency blocs



# Copula inference 4/5: Kendall plot

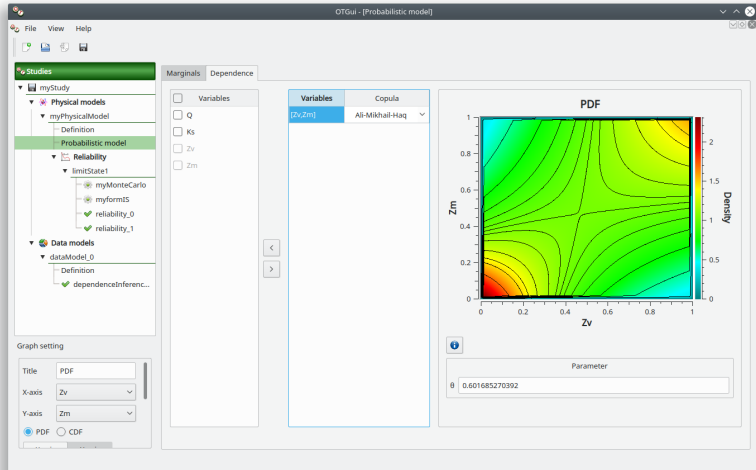


## Copula inference 5/5: pdf



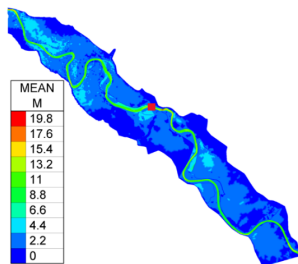


# Probabilistic model copulas



## Future work

- ▶ Vector-Field models (first 1-d meshes)
- ▶ Parallel evaluation (Python)
- ▶ Remote computations (YACS engine)



# END

Thank you for your attention!  
Any questions?



# Bibliography

- ▶ Airbus, EDF, Phimeca Engineering, IMACS. OpenTURNS, a scientific library usable as a Python module dedicated to the treatment of uncertainties, [www.openturns.org](http://www.openturns.org).
- ▶ Airbus, EDF, Phimeca Engineering, IMACS. Documentation of OpenTURNS, version 1.9.  
<http://openturns.github.io/openturns/1.9/contents.html>
- ▶ Michaël Baudin, Anne Dutfoy, Bertrand Iooss, and Anne-Laure Popelin. OpenTURNS: An Industrial Software for Uncertainty Quantification in Simulation, Handbook of Uncertainty Quantification, pages 1-38. Springer International Publishing, 2016
- ▶ Open TELEMAT-MASCARET. Electricité de France, Sogreah, Hydraulic Research Wallingford, Centre d'Etudes Techniques Maritimes et Fluviales, Bundesanstalt für Wasserbau, and Daresbury Laboratory. [www.opentelemat.org](http://www.opentelemat.org).