The graphical user interface of OpenTURNS, a UQ software in simulation

Michaël Baudin [1] Anne Dutfoy [1] Anthony Geay [1] Anne-Laure Popelin [1] Aurélie Ladier [2] Julien Schueller [2] Thierry Yalamas [2]

[1]EDF R&D. 6, quai Watier, 78401, Chatou Cedex - France, michael.baudin@edf.fr

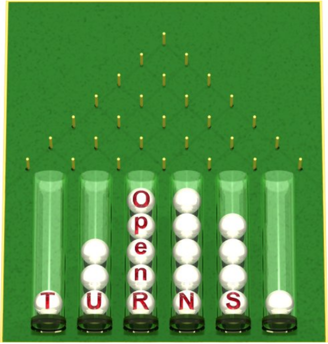
[2]Phimeca Engineering. 18/20 boulevard de Reuilly, 75012 Paris - France, yalamas@phimeca.com

15 June 2017, UNCECOMP 2017, Rhodes, Greece

Contents

OpenTURNS

- Uncertainty quantification, uncertainty propagation, sensitivity analysis and metamodeling
- Partners : EDF, Phiméca, Airbus, IMACS
- `www.openturns.org`
- Licence LGPL
- Linux, Windows

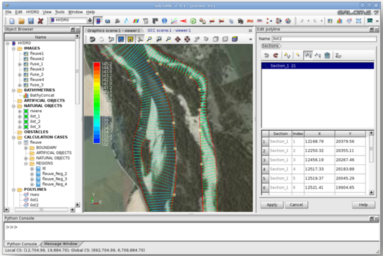


Programming:

- Python module
- C++ Library

SALOME

- Integration platform for pre and post processing, and 2D/3D numerical simulation
- Features : geometry, mesh, distributed computing
- Visualization, data assimilation, uncertainty treatment
- Partners : EDF, CEA, Open Cascade
- Licence : LGPL
- Linux, Windows
- `www.salome-platform.org`



The graphical user interface of OpenTURNS

- Main goal : provide a graphical interface of OpenTURNS in SALOME
- Features
  - Uncertainty quantification (distribution fitting), central tendency, sensitivity analysis, probability estimate, meta-modeling
  - Generic (not dedicated to a specific application)
  - GUI language : English, French
- Partners : EDF, Phiméca
- Licence : LGPL
- Schedule :
  - Since summer 2016, one EDF release per year
  - On the internet : 2018

GUI : the demo

Demo time.

GUI : outline

- From scratch : 3 inputs, 2 outputs, sum, central dispersion study with default parameters
- Open axialStressedBeam-python.xml : central dispersion with sample size 1000, Threshold P(G<0) with CV=0.05
- Import crue-4vars-analytique.py : S.A. with sample size 1000, sort by size

UQ, the easy way

Main goal : make UQ easy to use

- classical user-friendly algorithms with a state-of-the-art implementation,
- default parameters of the algorithms whenever possible,
- an easy access to the HPC resources,
- an automated connection to the computer code.

Produce standard results :

- numerical results e.g. tables,
- classical graphics.

Overview (1/2)

Inputs from the user :

- Physical model : symbolic, Python code or SALOME component
- Probabilistic model : joint probability distribution function of the input.

Then :

- Central dispersion: estimates the central dispersion of the output Y (e.g. mean).
- Threshold probability: estimates the probability that the output exceeds a given threshold S.
- Sensitivity analysis: estimates the importance of the inputs to the variability of the output.

Overview (2/2)

Probabilistic modeling :

- Distribution fitting from a sample
- Dependence modeling (Gaussian copula)

Meta-modeling :

- Polynomial chaos (full or sparse)
- Kriging

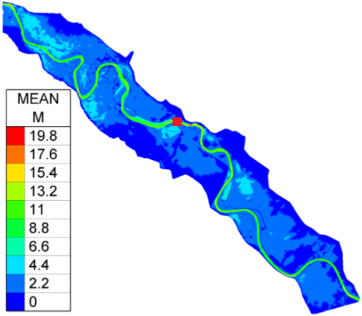
Fields

Field example :

- Input : 4 independent random variables
- Output : height of the river Garonne on a 100 km segment
- Computer code : TELEMAC2D
- Quantity of interest : pointwise average over 70 000 random simulations

Roadmap :

- Now : massive Python/OpenTURNS scripting
- 2017-2018 : in the gui

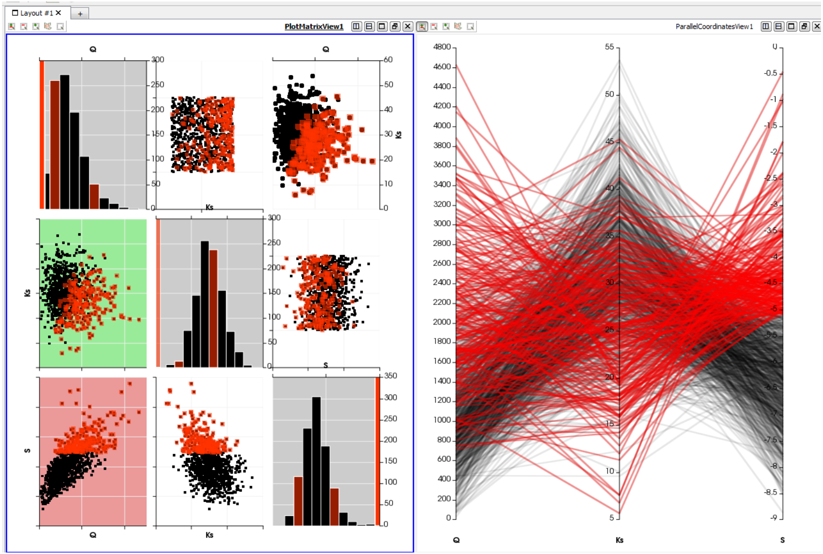


The end

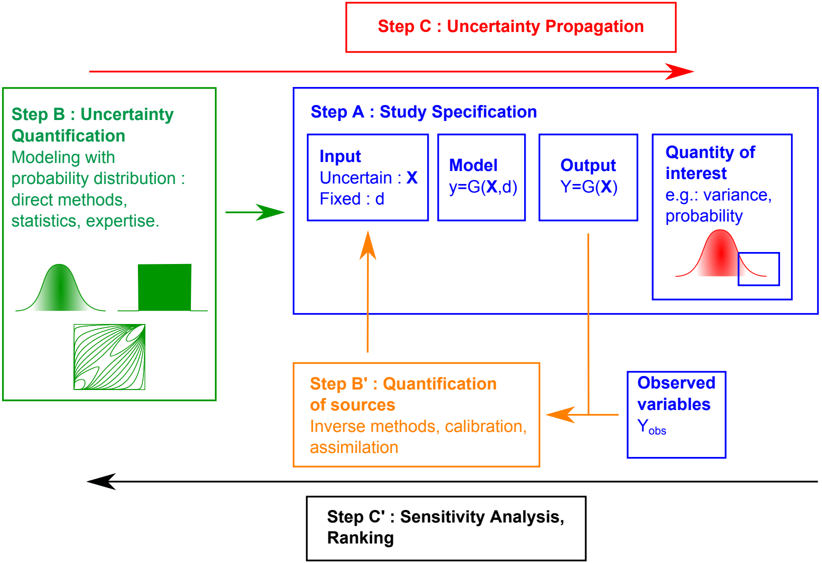
Thanks !

Questions ?

Interactive uncertainty visualization with Paraview



Methodology



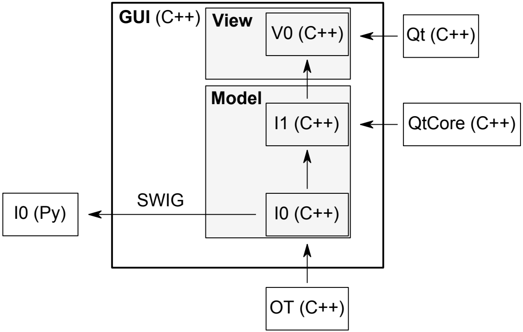
Software architecture

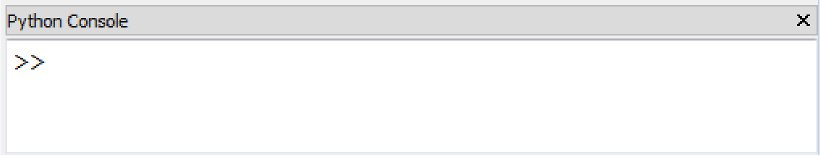
Two entry points:

- interactive,
- Python.

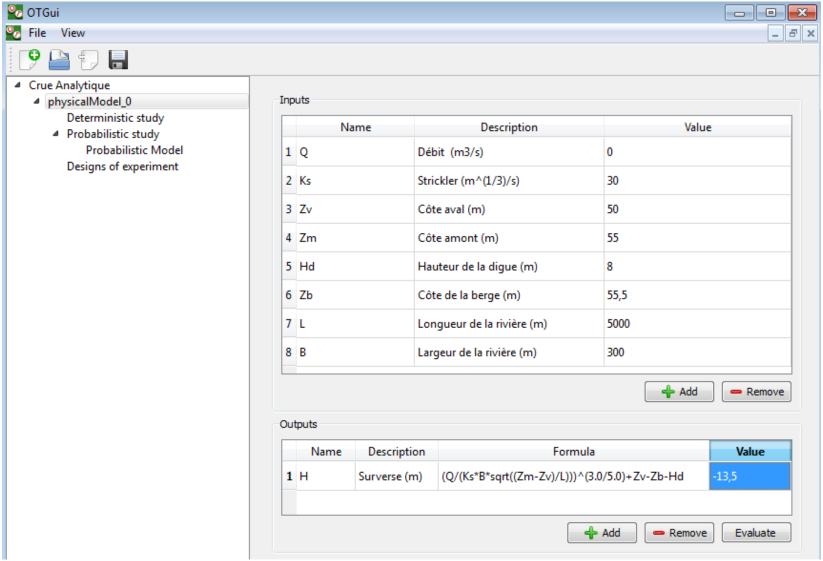
Advantages of the Python programming of the GUI:

- unit tests,
- going beyond the GUI

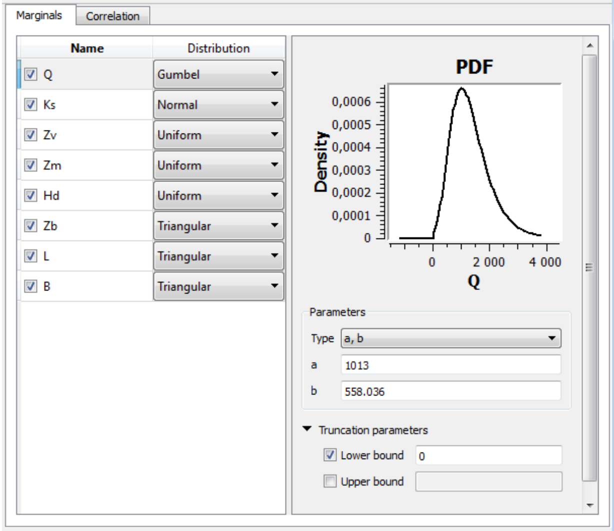




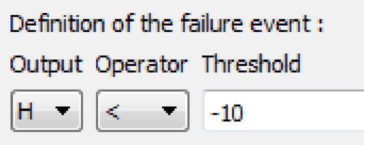
Symbolic physical model



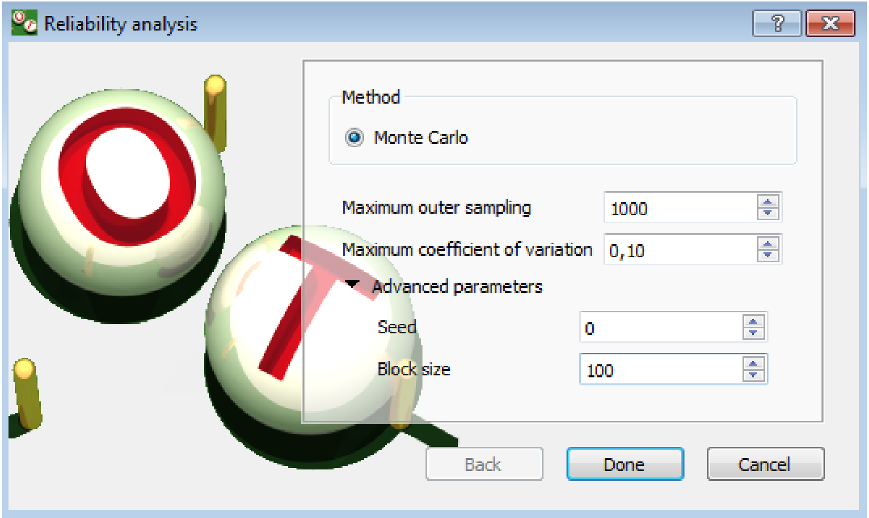
Probabilistic model



Limit state study : definition of the threshold



Limit state study : algorithm parameters



Limit state study : summary

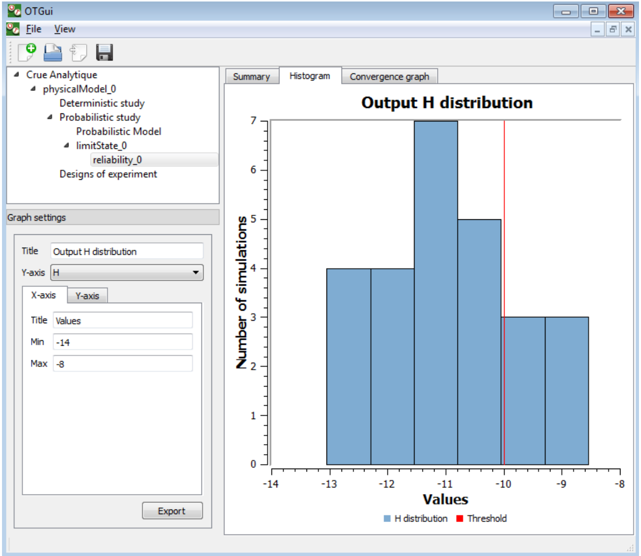
Summary | Histogram | Convergence graph

Output H

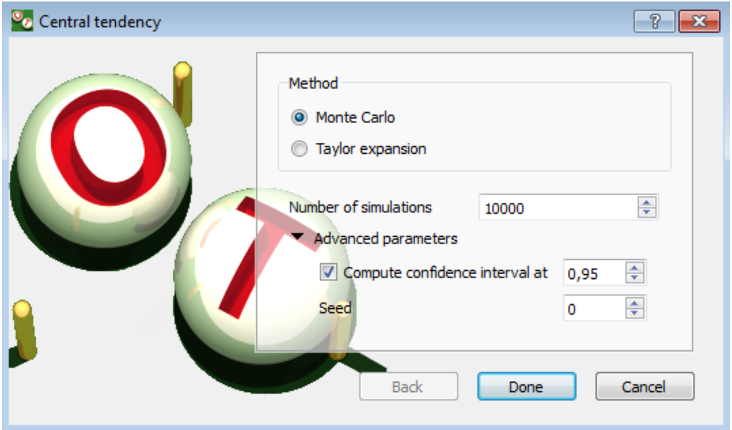
Number of simulations: 26

Estimate	Value	Confidence interval at 95%	
		Lower bound	Upper bound
Failure probability	0.807692	0.656203	0.959182
Coefficient of variation	0.0956949		

Limit state study : histogram



Central tendency : algorithm parameters



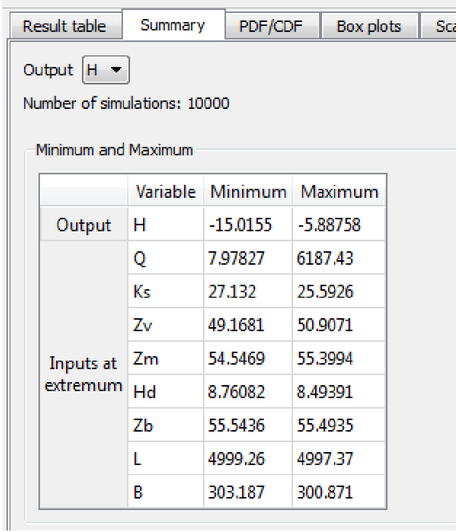
Central tendency : summary results

Moments estimate

Estimate	Value	Confidence interval at 95%	
		Lower bound	Upper bound
Mean	-11.0178	-11.0417	-10.9938
Standard deviation	1.22309	1.20637	1.24028
Skewness	0.20005		
Kurtosis	3.01907		
First quartile	-11.8721		
Third quartile	-10.2129		

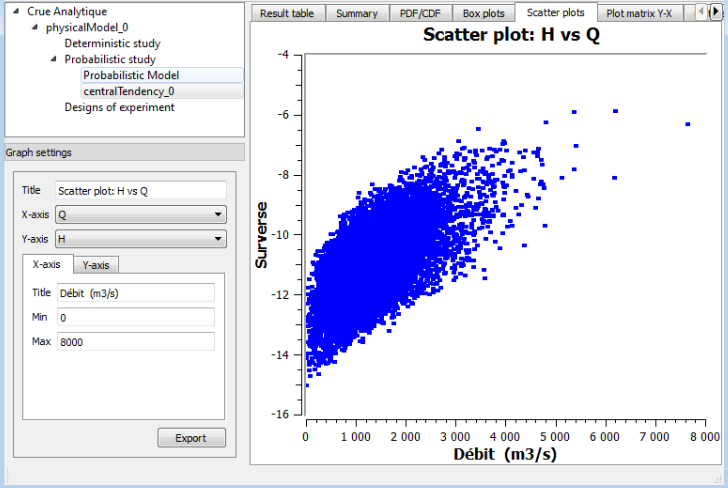
Probability 0,50 **Quantile** -11,04288948

Central tendency : summary results

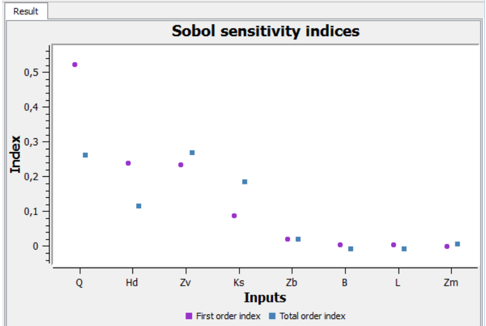


	Variable	Minimum	Maximum
Output	H	-15.0155	-5.88758
Inputs at extremum	Q	7.97827	6187.43
	Ks	27.132	25.5926
	Zv	49.1681	50.9071
	Zm	54.5469	55.3994
	Hd	8.76082	8.49391
	Zb	55.5436	55.4935
	L	4999.26	4997.37
	B	303.187	300.871

Central tendency : scatter plots



Sensitivity analysis : Sobol' indices



Input	First order index	Total order index
Zv	0.2366	0.2707
Q	0.5246	⚠ 0.2646
Ks	0.08843	0.1881
Hd	0.2411	⚠ 0.1179
Zb	0.02115	0.02203
Zm	0.0002773	0.008043

Interactions -2.784 ⚠