



OpenTURNS UQ Software and its Graphical User interface

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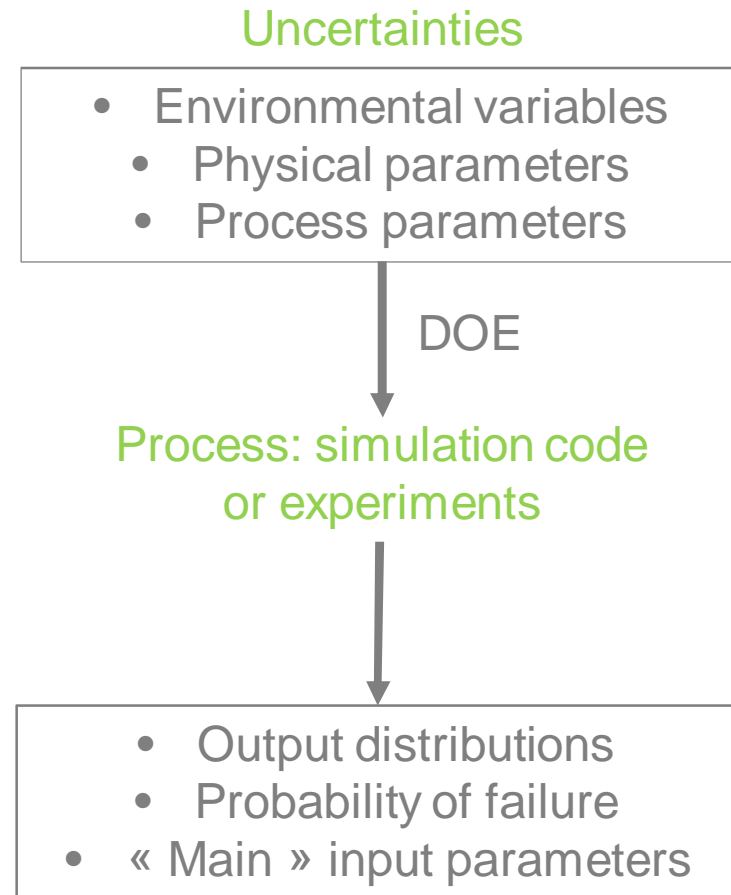
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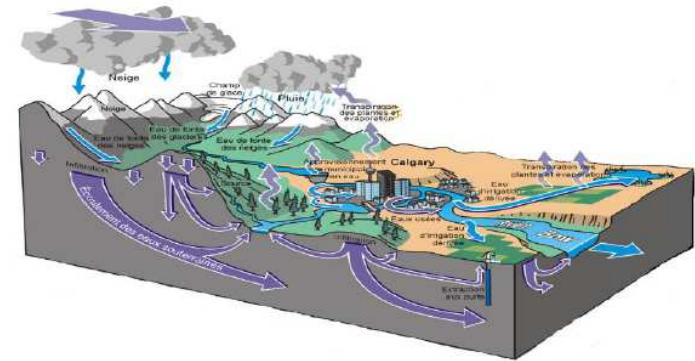
INDUSTRIAL CONTEXT - INTERESTS

- Exploratory study : **understand a phenomena**, an experimental or industrial process
- Safety study : evaluate a **safety margin** (failure probability, rare events)
- Design study : **optimizing** and control the performances



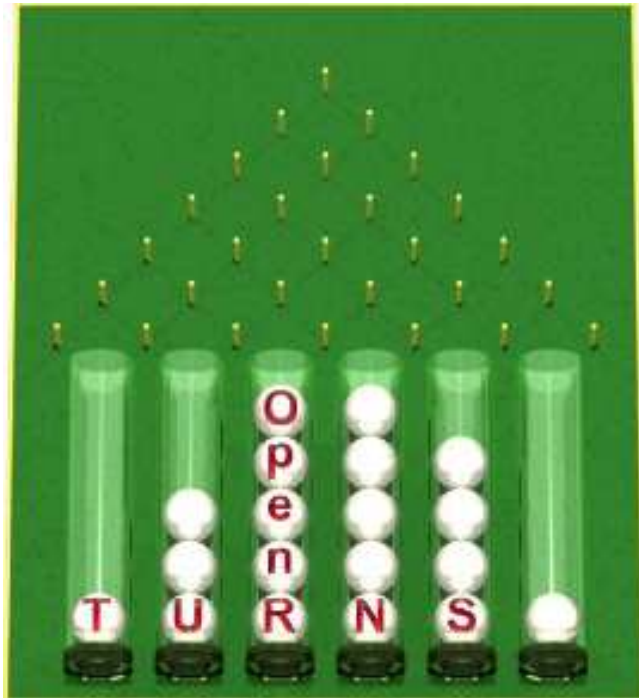
INDUSTRIAL CONTEXT - INTERESTS

- Exploratory study : **understand a phenomena**, an experimental or industrial process
 - Hydraulic model
- Safety study : evaluate a **safety margin** (failure probability, rare events)
 - Nuclear lifetime studies
- Design study : **optimizing** and control the performances
 - Renewable energy producible power



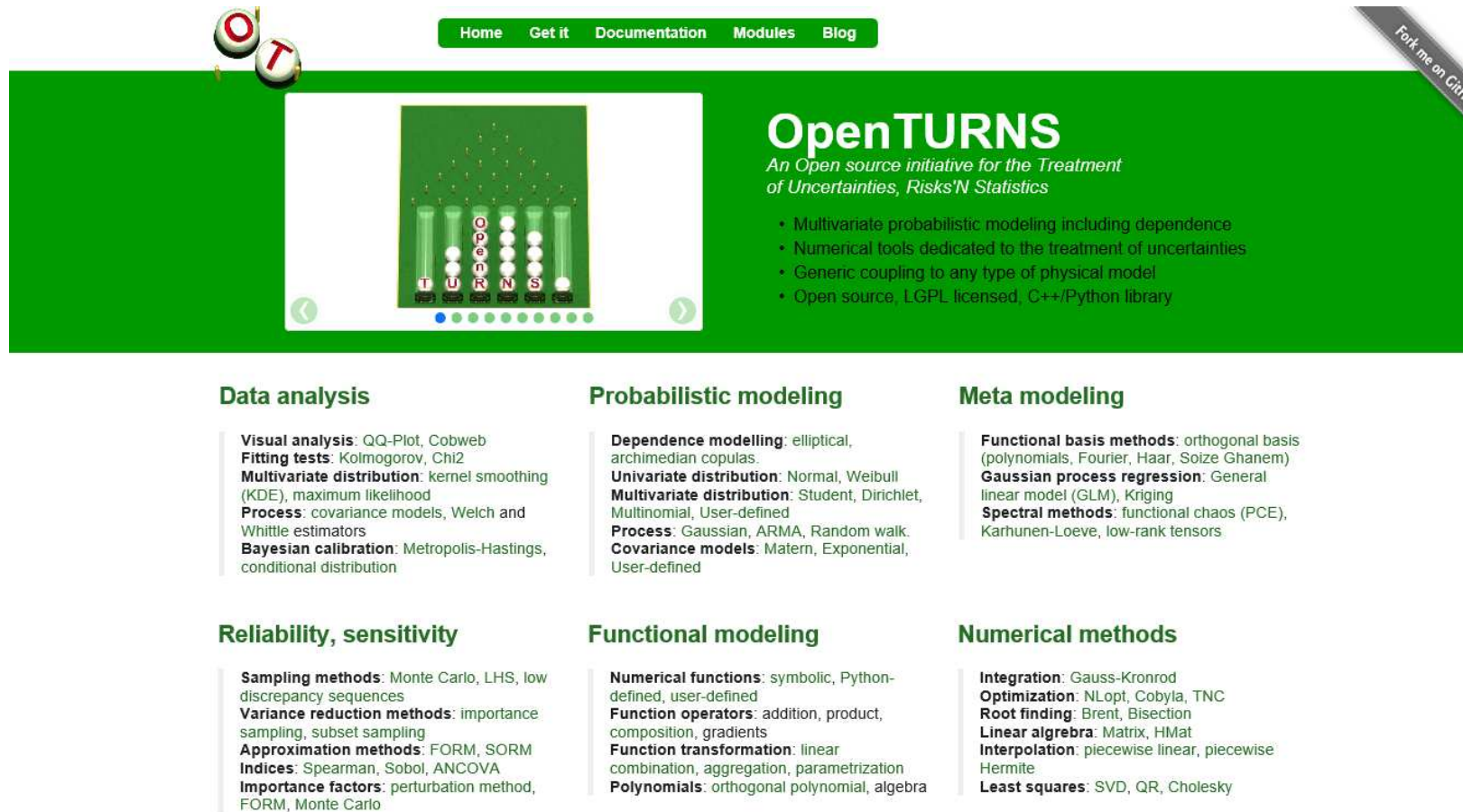
OPENTURNS : WWW.OPENTURNS.ORG

- Aims at adress a global framework : Uncertainty quantification, uncertainty propagation, sensitivity analysis and metamodeling



- 4 Partners :
 -  
 -  
- Since 2007
- LGPL licence
- Linux, Windows
- Programming:
 - Python module
 - C++ Library

OPENTURNS : WWW.OPENTURNS.ORG



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OpenTURNS
An Open source initiative for the Treatment of Uncertainties, Risks'N Statistics

- Multivariate probabilistic modeling including dependence
- Numerical tools dedicated to the treatment of uncertainties
- Generic coupling to any type of physical model
- Open source, LGPL licensed, C++/Python library

Data analysis

- Visual analysis:** QQ-Plot, Cobweb
- Fitting tests:** Kolmogorov, Chi2
- Multivariate distribution:** kernel smoothing (KDE), maximum likelihood
- Process:** covariance models, Welch and Whittle estimators
- Bayesian calibration:** Metropolis-Hastings, conditional distribution

Probabilistic modeling

- Dependence modelling:** elliptical, archimedean copulas.
- Univariate distribution:** Normal, Weibull
- Multivariate distribution:** Student, Dirichlet, Multinomial, User-defined
- Process:** Gaussian, ARMA, Random walk.
- Covariance models:** Matern, Exponential, User-defined

Meta modeling

- Functional basis methods:** orthogonal basis (polynomials, Fourier, Haar, Soize Ghanem)
- Gaussian process regression:** General linear model (GLM), Kriging
- Spectral methods:** functional chaos (PCE), Karhunen-Loeve, low-rank tensors

Reliability, sensitivity

- Sampling methods:** Monte Carlo, LHS, low discrepancy sequences
- Variance reduction methods:** importance sampling, subset sampling
- Approximation methods:** FORM, SORM
- Indices:** Spearman, Sobol, ANCOVA
- Importance factors:** perturbation method, FORM, Monte Carlo

Functional modeling

- Numerical functions:** symbolic, Python-defined, user-defined
- Function operators:** addition, product, composition, gradients
- Function transformation:** linear combination, aggregation, parametrization
- Polynomials:** orthogonal polynomial, algebra

Numerical methods

- Integration:** Gauss-Kronrod
- Optimization:** NLOpt, Cobyla, TNC
- Root finding:** Brent, Bisection
- Linear algebra:** Matrix, HMat
- Interpolation:** piecewise linear, piecewise Hermite
- Least squares:** SVD, QR, Cholesky

■ How to install it?

- Conda Python package
- Github
- Distributed in Debian

■ Online documentation

■ > 10000 downloads in 2017

■ Simulator : symbolic, Python, Salome, ...

BRING UNCERTAINTY METHODOLOGY TO ENGINEERS

- **3 years ago**

- EDF R&D wanted to maximize the use of OpenTURNS and UQ approaches by its engineer/researcher → develop a GUI to ease the use
- Phimeca has already developed an “OpenTURNS GUI” (PhimecaSoft®) which satisfy some needs of EDF R&D but not all.
- EDF R&D and Phimeca decided to start a specific partnership in order to develop a new GUI based on OpenTURNS and “Salome Tools” : Paraview, Yacs, ...

- **This new OT GUI is now available on Salome website, in EDF Specific Salome version**

<http://www.salome-platform.org/contributions>

- **Windows versions are only for partners : please contact us !**

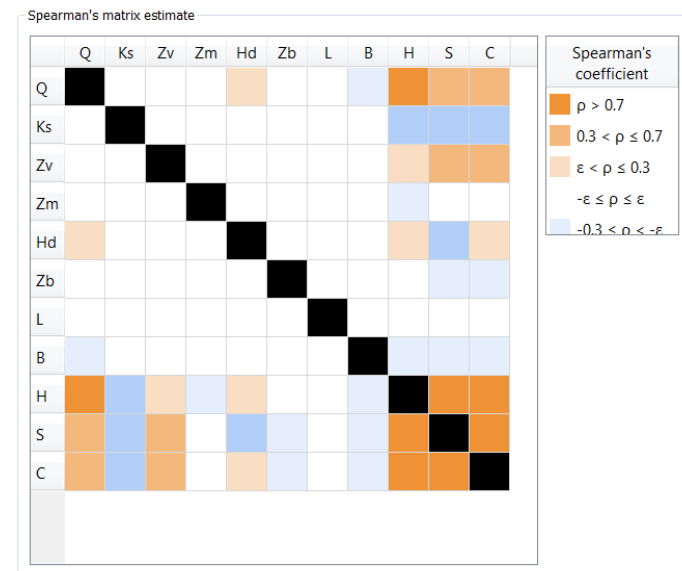
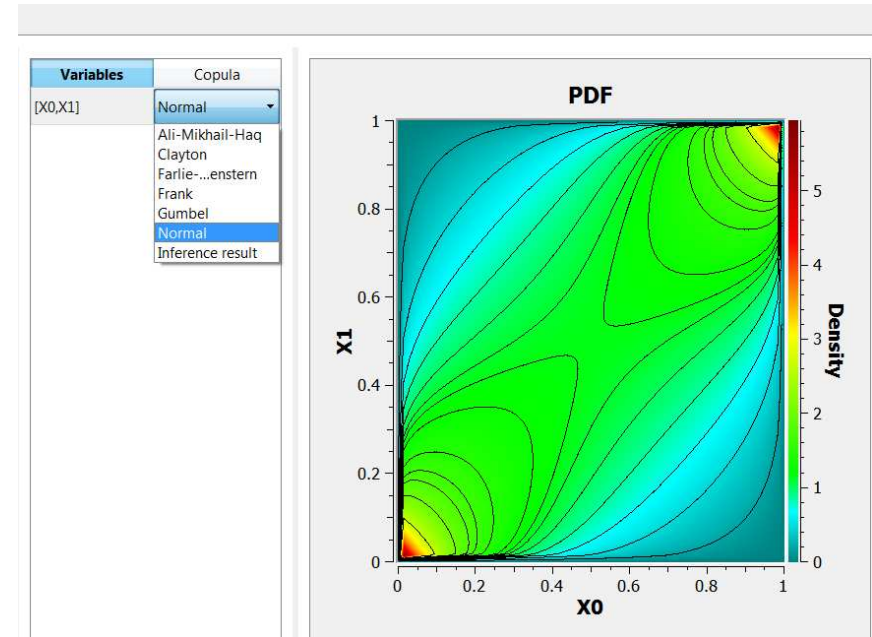
SOME EXPECTATIONS REGARDING THE GUI

- As easy to use as possible : UQ approaches spreading should not be restricted due to a problem of usability
- Support the methodology : guide the user
- For who? Variety of physics and codes at EDF
 - Generic (not dedicated to a specific application)
 - Linux : inside simulation platform SALOME (field physics : pre and post-processing tools, HPC resources access, ...)
 - Windows : address the system-models users (e.g. Modelica)
 - Trainings : symbolic formulas
- Possibility to generate a Python script usable without the platform in an “expert” mode
- GUI language : English, French

DEMO TIME

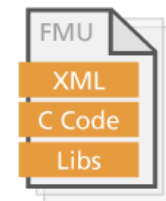
NEW FEATURES

- Morris method to select input variables
- Improved metamodel validation
- Sobol' sensitivity indices have confidence intervals
- Monte Carlo analysis manages failed points
- Dependence (copula) : definition and inference
- Optimization
- Link to the FMI models



SYSTEM MODELS : LINK USING FMI STANDARD

- Modelica is an open language for programming models based on differential algebraic systems of equations
- Main tools : Dymola (Dassault Systèmes, proprietary), Open Modelica (open source Modelica Consortium)
- FMI (Functional Mock-up Interface) is a standard for input–output data interface for numerical model.
- a FMU file contains : a xml description, a binary to evaluate the model



Propriétés Variables Différentiation

Filtres

Nom ☐ Casse Variabilité Causalité E/S

Variables

- ▶ sensorARE4
- ▲ sensorARE2
 - ▶ fluidInletI
 - ▶ fluidOutletI
 - ▲ N2OYD
 - continuous_flow_reversal
 - Q
 - ▶ Measure
 - ▶ C1
 - ▶ C2

E/S

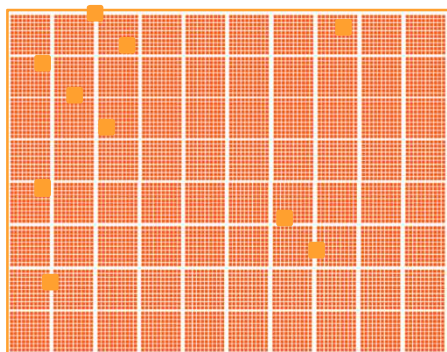
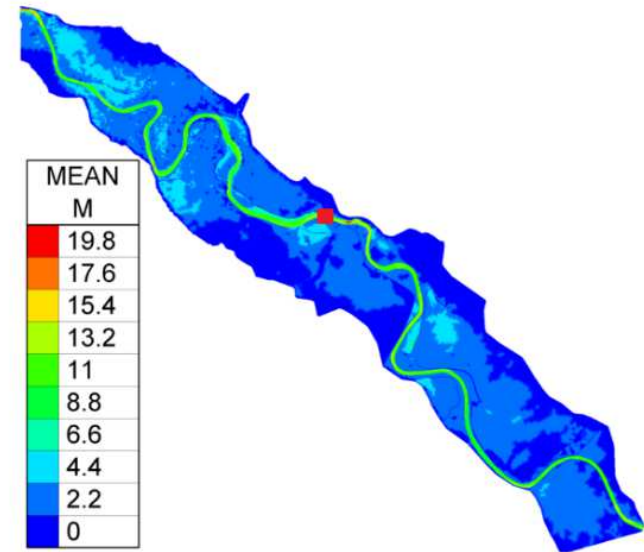
- ☐ Désactivé
- ☒ Entrée
- ☒ Sortie

Nom	Description	Variabilité	Causalité	E/S	Valeur
QARE0	Débit du système d'injection	Fixe	Paramètre	Entrée	2126,27
PARE0	Pression du système d'injection	Fixe	Paramètre	Entrée	7032780
TARE0	Température du système d'injecti...	Fixe	Paramètre	Entrée	499,9305
PGCT0	Pression	Fixe	Paramètre	Entrée	6540000
QGSS0	Débit du sécheur surchauffeur	Fixe	Paramètre	Entrée	183,4088889
QGRE0	Débit du flux de vapeur vers la tu...	Fixe	Paramètre	Entrée	1922,635556
BIL100....	Bilan de puissance thermique (W)	Fixe	Locale	Sortie	0

Variables sélectionnées : entrée : 6, sortie : 1

PERSPECTIVES AND CHALLENGES

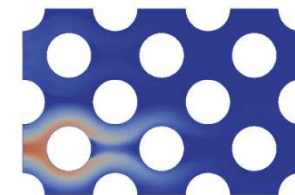
- A new module dedicated to random fields analysis
 - Extend the methodology : more complex tools
 - Interface with codes that manage inputs and outputs as fields
 - Large data volume : in-situ challenge



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THANK YOU FOR YOUR ATTENTION

#11 Users Day – 15th June 2018 – Saclay, France
Come and join us!

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