

# PERSALYS, the graphical interface of OpenTURNS

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# Bring Uncertainty Methodology to Engineers

- ▶ 5 years ago
  - ▶ EDF R&D wants to maximize the use of OpenURNS® by its engineer/researcher (and improve an existing GUI) => develop a GUI to make more easy to use
  - ▶ Phimeca has already developed an "OpenURNS GUI" (PhimecaSoft®) which satisfy some needs of EDF R&D but not all.
  - ▶ EDF R&D and Phimeca decide to start a specific partnership in order to develop a new GUI based on OpenURNS® and "Salome Tools": Paraview, Yacs, ...
- ▶ Persalys is available, on Salome website, in EDF Specific Salome version and commercialized by Phimeca

## Some expectations regarding the GUI

- ▶ As easy to use as possible and, when it is possible, a GUI which can guide the user
- ▶ Possibility to use it inside Salome Platform to
  - ▶ Use supercomputing resources (e.g. Gaïa, 3 052 Tflops peak, 41 000 cores)
  - ▶ Connect to EDF numerical code users (Code\_Aster for example)
- ▶ Take benefit from the advanced visualization capability from Paraview
- ▶ Drive the GUI from a python script usable in an "expert" mode

# PERSALYS, the graphical user interface of OpenTURNS

- ▶ Main goal : provide a graphical interface of OpenTURNS in the SALOME integration platform
- ▶ Features
  - ▶ Uncertainty quantification : definition of the probabilistic model (including dependence), distribution fitting (including copulas), physical model with vector input and vector output or 1D Fields, central tendency, sensitivity analysis, probability estimate, metamodeling (polynomial chaos, kriging), screening (Morris), optimization, design of experiments
  - ▶ 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 (free) : SALOME\_EDF in the "CONTRIBUTIONS" section since 2018 on <https://www.salome-platform.org>

# Calibration

Given a physical model  $H$ , observed inputs  $x$ , observed outputs  $y$  we can calibrate  $\theta$  so that

$$y_i = H(x_i, \theta) + \epsilon$$

where  $\epsilon$  is a random variable.

Calibration outputs:

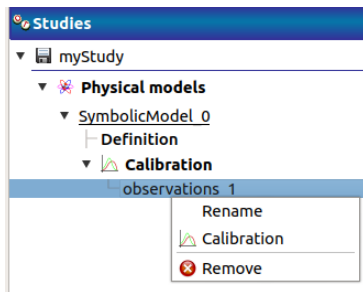
- ▶ the optimal value  $\theta^*$ ,
- ▶ the distribution of  $\theta^*$ ,
- ▶ the distribution of the residuals  $r_i = y_i - H(x_i, \theta^*)$ .

This allows to get confidence intervals of  $\theta^*$ .

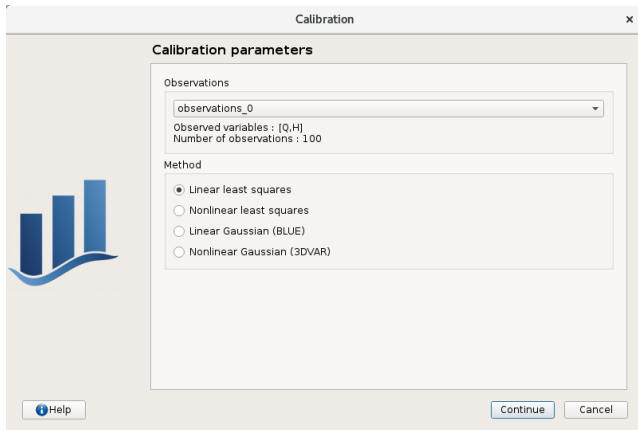
# Calibration

In PERSALYS, this requires:

- ▶ a physical model  $H$ ,
- ▶ a data file containing the observed inputs and outputs.




# Calibration





# Calibration



### Calibration

Choose the input variables to calibrate and define the reference point of the algorithm

Number of inputs to calibrate :

	<input checked="" type="checkbox"/> Name	Description	Value
1	<input checked="" type="checkbox"/> Ks	Strickler ( $m^{1/3}/s$ )	20
2	<input checked="" type="checkbox"/> Zv	Côte de la rivière en aval (m)	49
3	<input checked="" type="checkbox"/> Zm	Côte de la rivière en amont (m)	51

[Help](#)[Back](#)[Continue](#)[Cancel](#)

# Calibration



## Calibration

### Gaussian prior distribution

Define the covariance matrix of the parameters  $\theta$  to calibrate.

Marginals

Dependence

	Variable	Distribution
1	Ks	Normal
2	Zv	Normal
3	Zm	Normal



PDF

Density

Ks

Parameters

$\mu$  20

$\sigma$  2

Help

Back

Continue

Cancel

# Calibration

Calibration

Output

H

$\theta$

Prediction

Parameters

Model

Optimal

PDF

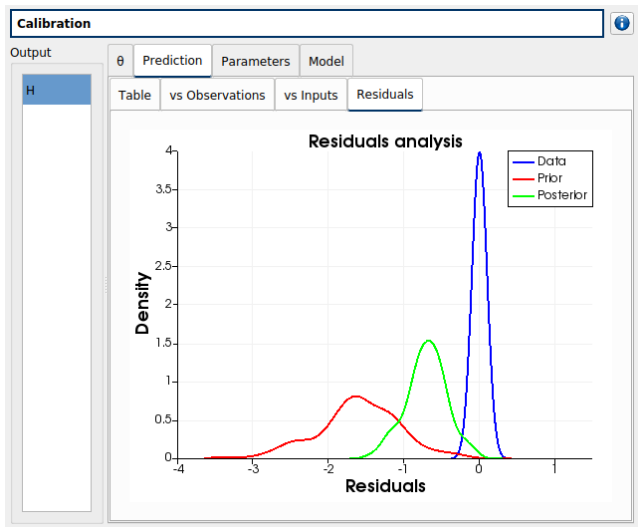
Optimal  $\theta$

Input	Value	Confidence interval at 95%
Ks	20.0432	[15.5523, 24.5341]
Zv	47.7043	[39.7458, 55.6628]
Zm	52.4036	[44.4431, 60.3641]

# Calibration



# Calibration



# Calibration

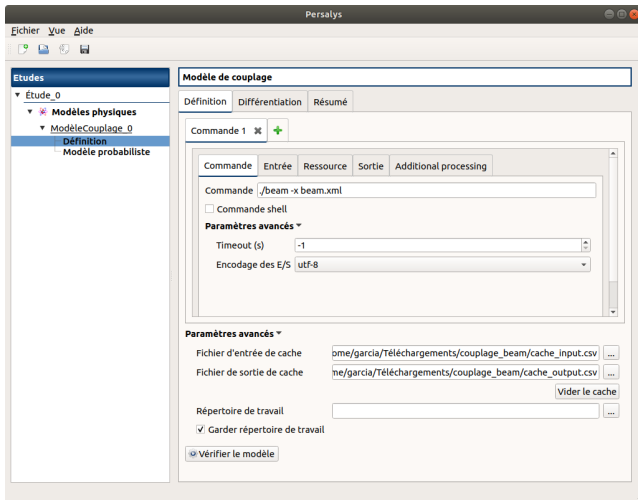


## Coupling with external code

A new physical coupling dialog was created:

- ▶ Execute any computer code from system e.g. with command line statement
- ▶ Create a pipeline of commands
- ▶ Exchange data with input and output files
- ▶ Manage input and output cache to save simulations
- ▶ Can be parallel : multithread or distributed (in SALOME)
- ▶ Makes the tuning of input template file and the reading of output files easy

# Coupling with external code





# Coupling with external code

A diff can be generated between the input template and the actual input file.

The screenshot shows the Persalys software interface. The main window is titled 'Modèle de couplage'. It has a sidebar on the left with a tree view showing 'Etudes', 'Modèles physiques', 'ModèleCouplage\_0', 'Définition', and 'Modèle probabiliste'. The main area is divided into several sections:

- Modèle de couplage**: A tabbed interface with 'Définition', 'Différentiation', and 'Résumé' tabs. The 'Définition' tab is active.
- Commande 1**: A section with a '+' icon and a 'Fichier' icon.
- Fichier modèle**: A text field containing the path '/home/garcia/Téléchargements/couplage\_beam/beam\_input\_template.xml'.
- Fichier configuré**: A text field containing the name 'beam.xml'.
- Table**: A table with 5 columns: 'Nom', 'Description', 'Marqueur', 'Valeur', and 'Format'. It contains 4 rows of data.
 

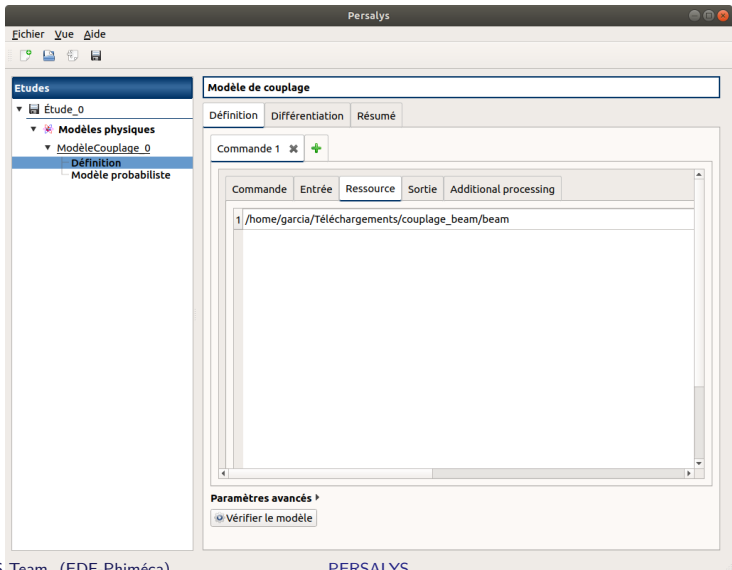
Nom	Description	Marqueur	Valeur	Format
1 E		@E	2	()
2 F		@F	30000	()
3 I		@I	1	()
4 L		@L	5	()
- Vérifier fichier modèle**: A button with a green plus icon and the text 'Ajouter' and 'Supprimer'.
- Comparaison modèle/entrée**: A section showing two XML snippets side-by-side. The left snippet is the template, and the right snippet is the actual input file. The differences are highlighted in red.
 

```
<?xml version="1.0"?>
<beam>
  <description name="beam" title="UseCase beam with XML input file" version="1.0" date="2014-04-07">
    <tool name="beam exe" version="1.0"/>
  </description>
  <inputs F="0" E="0" L="0" I="0"/>
  <computation>
    <derivate activate="on"/>
    <hessian activate="off"/>
  </computation>
</beam>
```

```
<?xml version="1.0"?>
<beam>
  <description name="beam" title="UseCase beam with XML input file" version="1.0" date="2014-04-07">
    <tool name="beam exe" version="1.0"/>
  </description>
  <inputs F="30000" E="2" L="5" I="1"/>
  <computation>
    <derivate activate="on"/>
    <hessian activate="off"/>
  </computation>
</beam>
```
- Paramètres avancés**: A section with a '+' icon and a 'Vérifier le modèle' button.

# Coupling with external code

Resources are files to copy to run the simulation : mesh, parameters, etc...



# Coupling with external code

Persalys

Fichier Vue Aide

Etudes

- Étude\_0
  - Modèles physiques
    - ModèleCouplage\_0
      - Définition
      - Modèle probabiliste

Modèle de couplage

Définition Différentiation Résumé

Commande 1 X +

Commande Entrée Ressource Sortie Additional processing

Fichier X +

Fichier de sortie \_beam\_outputs.xml

Nom	Description	Marqueur	Saut de marqueur	Saut de ligne	Saut de colonne	Valeur
1 deviation	deviation="	0	0	0	625000	

Vérifier sortie

deviation=0.130208

+Ajouter -Supprimer

Paramètres avancés

Fichier d'entrée de cache /home/garcia/Téléchargements/couplage\_beam/cache\_input.csv

Fichier de sortie de cache /home/garcia/Téléchargements/couplage\_beam/cache\_output.csv

Répertoire de travail

✓ Garder répertoire de travail

Vérifier le modèle

Vider le cache

# Coupling with external code

On-disk cache management: one input point  $X$  is only evaluated once.

**Cache** ▾

Cache input file	<input type="text" value="/home/osboxes/CouplingCase-A/cache.in.txt"/>	<input type="button" value="..."/>
Cache output file	<input type="text" value="/home/osboxes/CouplingCase-A/cache.out.txt"/>	<input type="button" value="..."/>

# Website

`persalys.fr` : download (source, binaries), doc (videos tutorials), news



The screenshot shows the homepage of the Persalys website. At the top, there is a navigation bar with the following links: Persalys, Fonctionnalités, Obtenir, Actualités, and Documentation. The main heading is "Persalys" with a logo consisting of three vertical bars of increasing height. Below the heading, a paragraph states: "Persalys est une interface graphique dédiée au **traitement des incertitudes et la gestion des variabilités**. Le logiciel est un outil à la frontière de la simulation numérique, des analyses probabilistes et des data sciences." Below this, it says "Persalys permet de :" followed by a bulleted list:

- créer des **modèles mathématiques**: analytique, couplage avec un modèle externe (éléments finis, ...), FMU
- **analyser la variabilité** de vos paramètres grâce à un grand nombre de méthodes et d'outils de visualisation
- **analyser vos données de mesures** statistiquement, inférer des distributions de probabilités ou encore créer des métamodèles

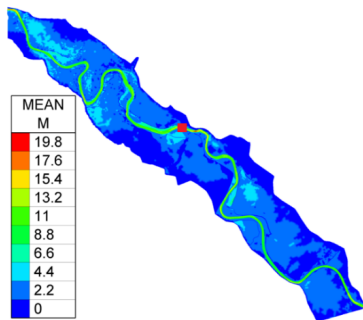
Below the list, there are three columns of information:

- Dernières actualités**: 10/04/2020 : Développement personnalisé : Penstock Pipe 24/02/2020 : Sortie de Persalys 8.0. A button "Voir les actualités" is at the bottom.
- Qui utilise Persalys ?**: Features the Phimeca logo (a stylized 'P' in a square) and the text "Développement et étude".
- Qui développe Persalys ?**: States "Persalys est développé en partenariat par Phimeca et EDF. Il est codé en C++ et Qt avec principalement la librairie OpenTURNS comme moteur de calcul." Below this are the logos for Phimeca, EDF, and OpenTURNS.

# What's next ?

## PERSALYS Roadmap :

- ▶ 2D Fields, 3D Fields
- ▶ In-Situ fields based on the MELISSA library (with INRIA): when we cannot store the whole sample in memory or on the hard drive, update the statistics (e.g. the mean, Sobol' indices) sequentially, with distributed computing.
- ▶ Linear regression.



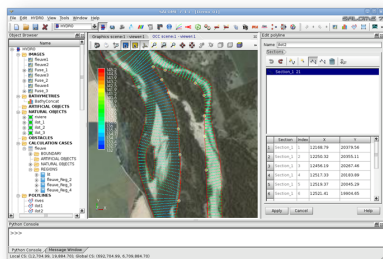
The end

Thanks !

Questions ?

# SALOME

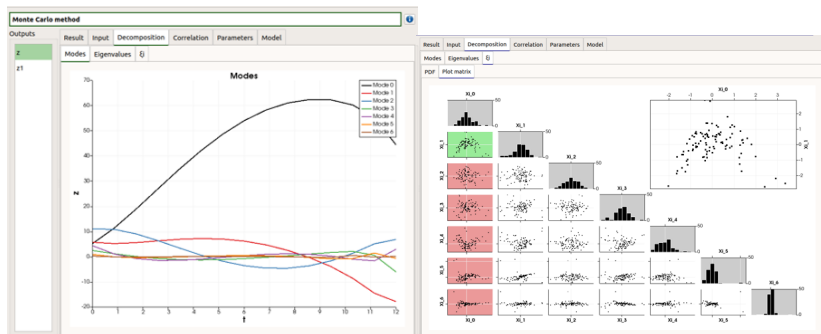
- ▶ Integration platform for pre and post processing, and 2D/3D numerical simulation
- ▶ Features : geometry, mesh, distributed computing
- ▶ Visualization, data assimilation, uncertainty treatment
- ▶ Partners : EDF, CEA, Open Cascade
- ▶ Licence : LGPL
- ▶ Linux, Windows
- ▶ [www.salome-platform.org](http://www.salome-platform.org)



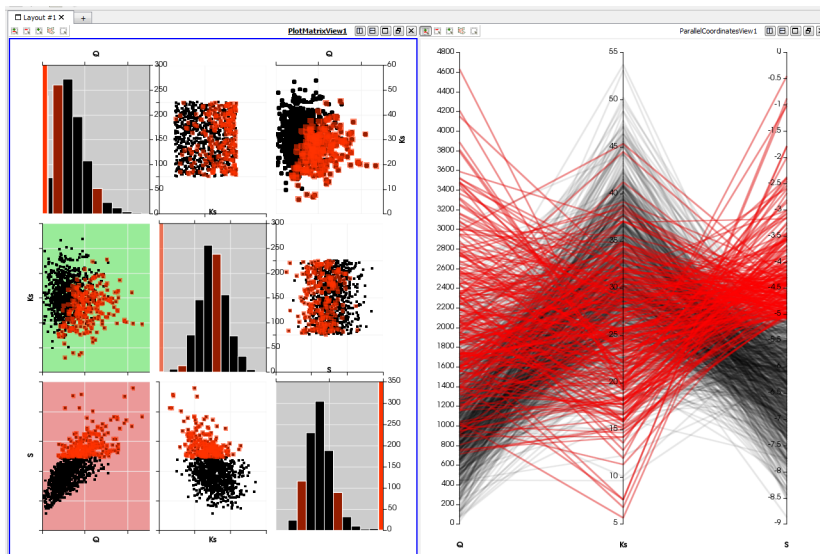


# PERSALYS: 1D fields

- ▶ Karhunen Loeve decomposition
- ▶ Show modes, eigenvalues and projection coefficients

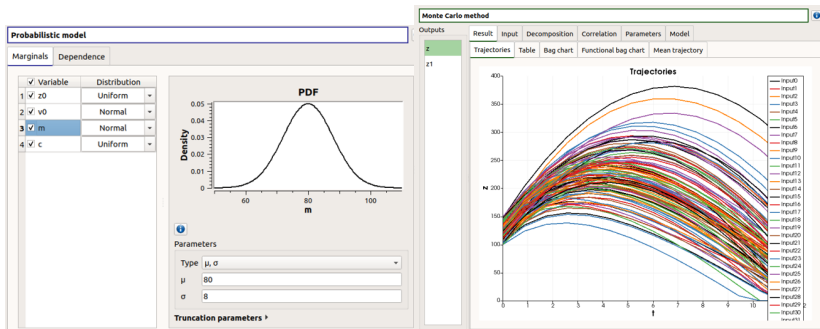


# Interactive uncertainty visualization with Paraview



# 1D fields

- ▶ Probabilistic model
- ▶ Uncertainty propagation with simple Monte-Carlo sampling



## 1D fields

- ▶ BagChart and Functional Bagchart (from Paraview) based on High Density Regions (Hyndman, 1996).
- ▶ To do this, Paraview uses a principal component analysis decomposition.
- ▶ Linked and interactive selections in the views.

