

# 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 OpenTURNS® by its engineer/researcher (and improve an existing GUI) => develop a GUI to make more easy to 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 decide to start a specific partnership in order to develop a new GUI based on OpenTURNS® 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:

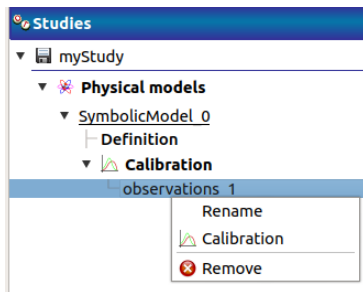
- ▶ the optimal value  $\theta^*$ ,
- ▶ the distribution of  $\theta^*$ ,
- ▶ the distribution of the residuals  $r_i = y_i - H(x_i, \theta^*)$ .

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

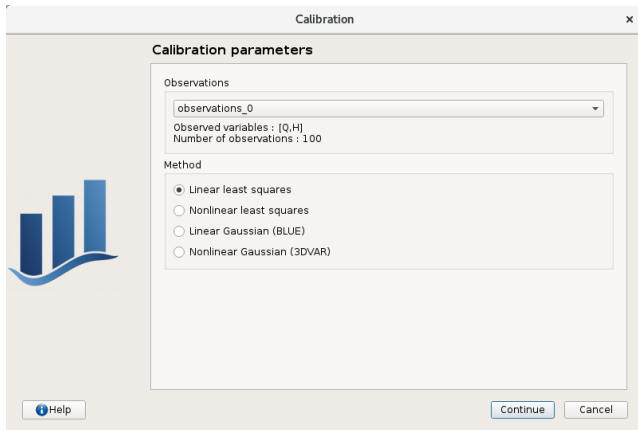
# Calibration

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



Parameters

$\mu$  20

$\sigma$  2

Help

Back

Continue

Cancel

# Calibration

Calibration

Output

H

$\theta$

Prediction

Parameters

Model

Optimal

PDF

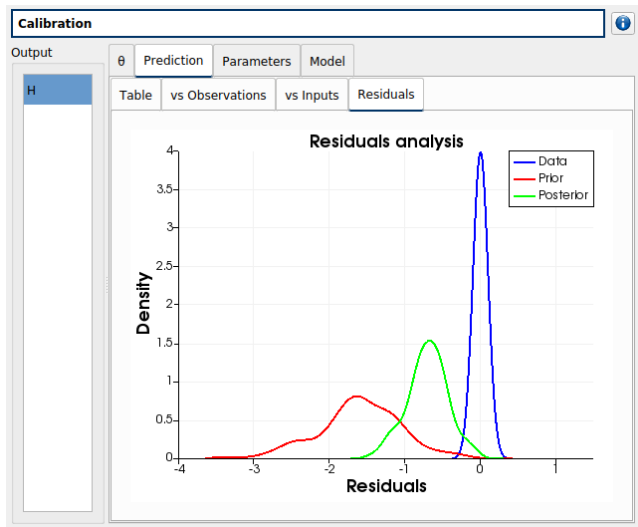
Optimal  $\theta$

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

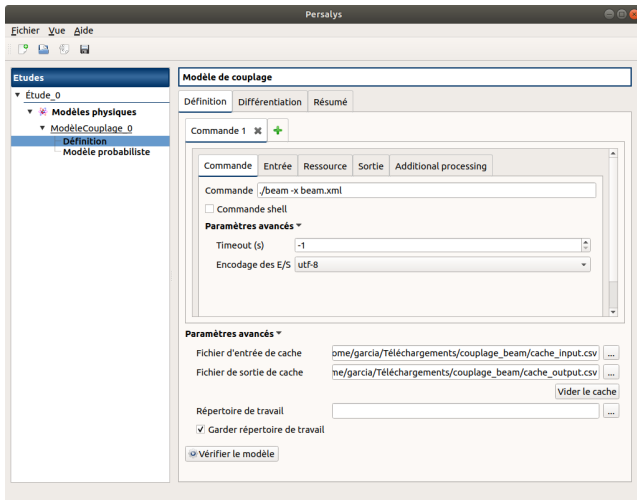


## Coupling with external code

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 application window. On the left is a sidebar with a tree view containing 'Etudes', 'Modèles physiques', 'ModèleCouplage\_0', 'Définition', and 'Modèle probabiliste'. The main area is titled 'Modèle de couplage' and has tabs for 'Définition', 'Différentiation', and 'Résumé'. The 'Définition' tab is active, showing 'Commande 1' with a green plus icon. Below this is a table with columns 'Nom', 'Description', 'Marqueur', 'Valeur', and 'Format'. The table contains four rows of data:

Nom	Description	Marqueur	Valeur	Format
1 E		@E	2	()
2 F		@F	30000	()
3 I		@I	1	()
4 L		@L	5	()

Below the table is a section for 'Comparer le modèle/entrée' with a 'Vérifier le modèle' button. It shows a side-by-side comparison of XML code. The left pane shows the template XML, and the right pane shows the actual input XML. The differences are highlighted in red in the right pane:

```
<?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>
```

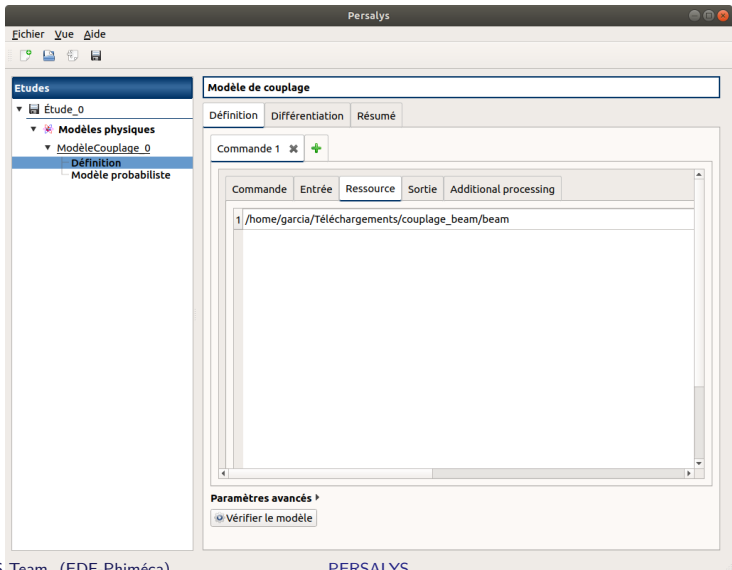
The right pane shows the actual input XML with the following differences highlighted in red:

```
<?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="30000" E="2" L="5" I="1"/>
  <computation>
    <derivate activate="on"/>
    <hessian activate="off"/>
  </computation>
</beam>
```

At the bottom of the window, there is a 'Paramètres avancés' section with 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. Below the navigation bar, a paragraph describes Persalys as a graphical interface for "traitement des incertitudes et la gestion des variabilités". It lists three main capabilities: creating mathematical models, analyzing variability, and analyzing measurement data. Below this, there are three featured sections: "Dernières actualités" (Latest news) with a link to a development update, "Qui utilise Persalys ?" (Who uses Persalys?) featuring the Phimeca logo, and "Qui développe Persalys ?" (Who develops Persalys?) mentioning Phimeca and EDF as partners.

**Persalys**

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.

Persalys permet de :

- 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

**Dernières actualités**

10/04/2020 : Développement personnalisé : Penstock Pipe  
24/02/2020 : Sortie de Persalys 8.0

[Voir les actualités](#)

**Qui utilise Persalys ?**

**PHIMECA**  
Solutions for nuclear engineering

Développement et étude

**Qui développe Persalys ?**

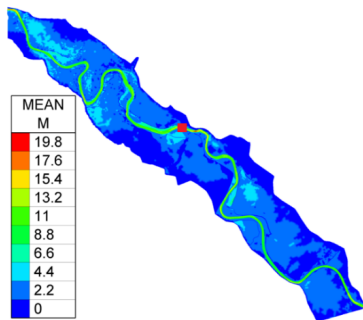
Persalys est développé en partenariat par Phimeca et EDF. Il est codé en C++ et Qt avec principalement la librairie OpenTURNS comme moteur de calcul.

**PHIMECA** **EDF**

# 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.



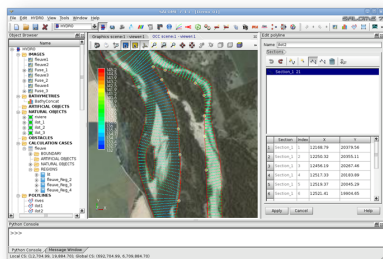
The end

Thanks !

Questions ?

# SALOME

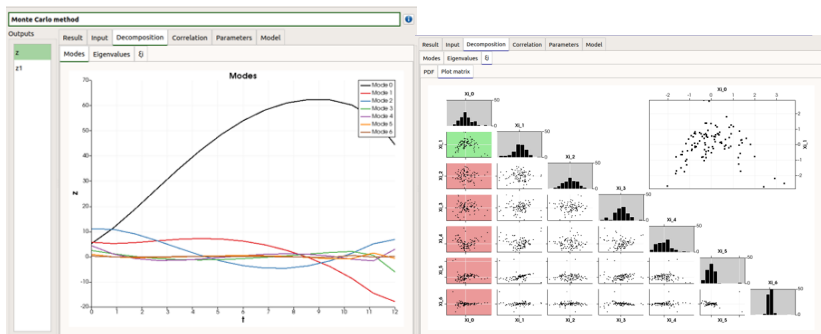
- ▶ Integration platform for pre and post processing, and 2D/3D numerical simulation
- ▶ Features : geometry, mesh, distributed computing
- ▶ Visualization, data assimilation, uncertainty treatment
- ▶ Partners : EDF, CEA, Open Cascade
- ▶ Licence : LGPL
- ▶ Linux, Windows
- ▶ [www.salome-platform.org](http://www.salome-platform.org)





# PERSALYS: 1D fields

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

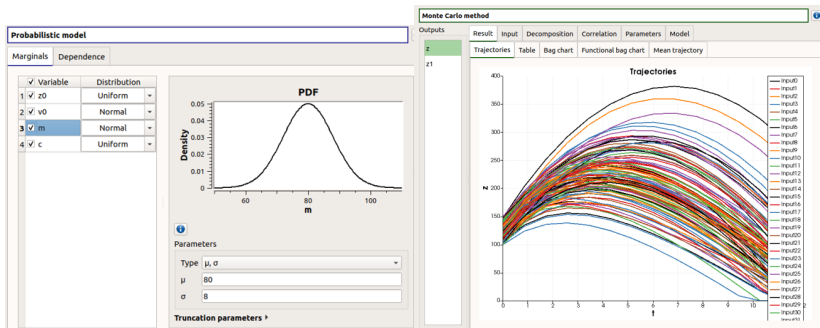


# Interactive uncertainty visualization with Paraview



# 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.

