

# PERSALYS, the graphical interface of OpenTURNS

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PERSALYS v8: Calibration

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What's next ?

# 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:

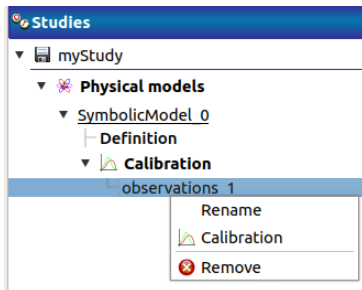
- ▶ the optimal value  $\theta^*$ ,
- ▶ the distribution of  $\theta^*$ ,
- ▶ the distribution of the residuals  $r_i = y_i - H(x_i, \theta^*)$ .

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

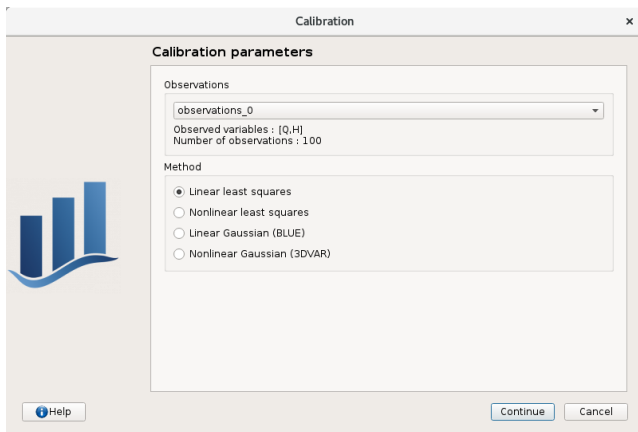
# Calibration

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

$\mu$

$\sigma$

Help

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Continue

Cancel

# Calibration

Calibration

Output

H

$\theta$

Prediction

Parameters

Model

Optimal

PDF

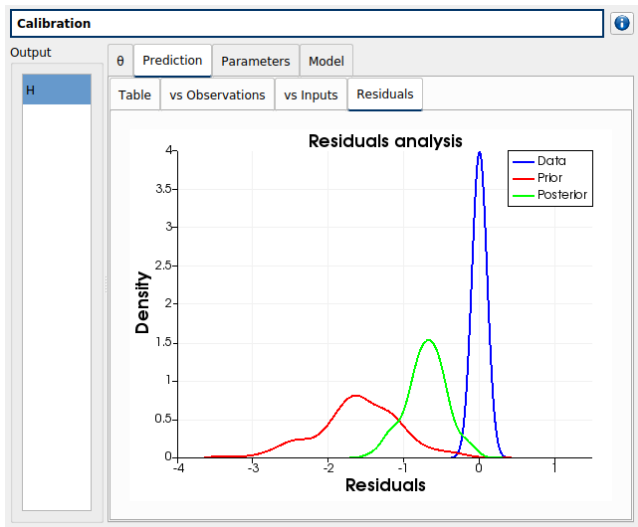
Optimal  $\theta$

| 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]         |

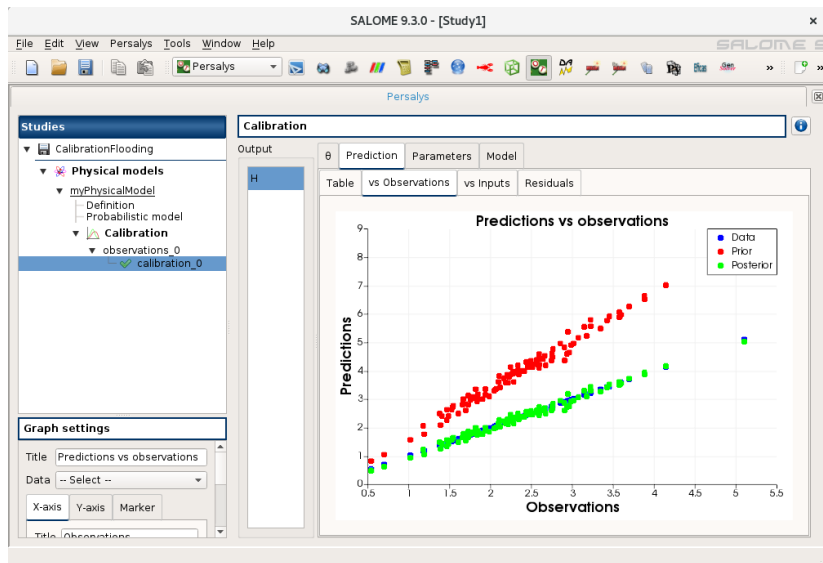
# Calibration



# 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', and 'Définition'. The main area is titled 'Modèle de couplage' and has three tabs: 'Définition', 'Différentiation', and 'Résumé'. The 'Définition' tab is selected.

Under the 'Définition' tab, there is a 'Commande 1' section with a '+' icon. Below it is a table with columns: 'Commande', 'Entrée', 'Ressource', 'Sortie', and 'Additional processing'. The table contains four rows of data:

| Commande | Entrée | Ressource | Sortie | Additional processing |
|----------|--------|-----------|--------|-----------------------|
| 1        | E      | ΦE        | 2      | 0                     |
| 2        | F      | ΦF        | 30000  | 0                     |
| 3        | I      | ΦI        | 1      | 0                     |
| 4        | L      | ΦL        | 5      | 0                     |

Below the table, there is a section 'Comparer modèle/entrée' with a '+' icon. It shows a comparison of two XML files. The left file is the template, and the right file is the actual input file. The comparison highlights differences in the 'inputs' and 'derivates' sections.

At the bottom, 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

Commande Entrée Ressource **Sortie** Additional processing

Fichier

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 Ajouter Supprimer

deviation=0.130208

**Paramètres avancés**

Fichier d'entrée de cache

Fichier de sortie de cache

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  ...

Cache output file  ...

# Website

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

Persalys

Persalys   Fonctionnalités   Obtenir   Actualités   Documentation

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.

# 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.



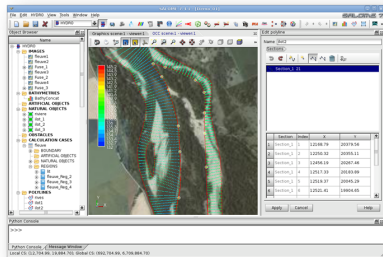
The end

Thanks !

Questions ?

# SALOME

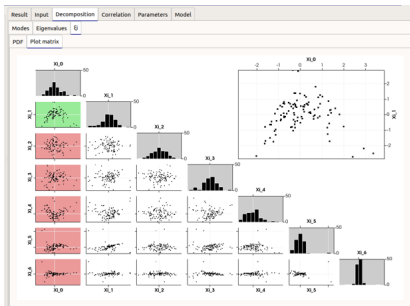
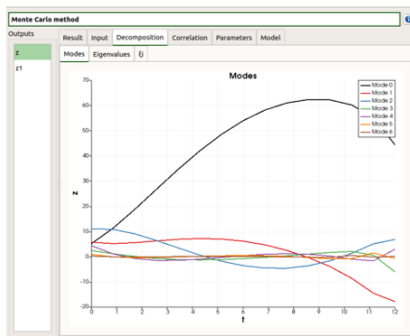
- ▶ Integration platform for pre and post processing, and 2D/3D numerical simulation
- ▶ Features : geometry, mesh, distributed computing
- ▶ Visualization, data assimilation, uncertainty treatment
- ▶ Partners : EDF, CEA, Open Cascade
- ▶ Licence : LGPL
- ▶ Linux, Windows
- ▶ [www.salome-platform.org](http://www.salome-platform.org)



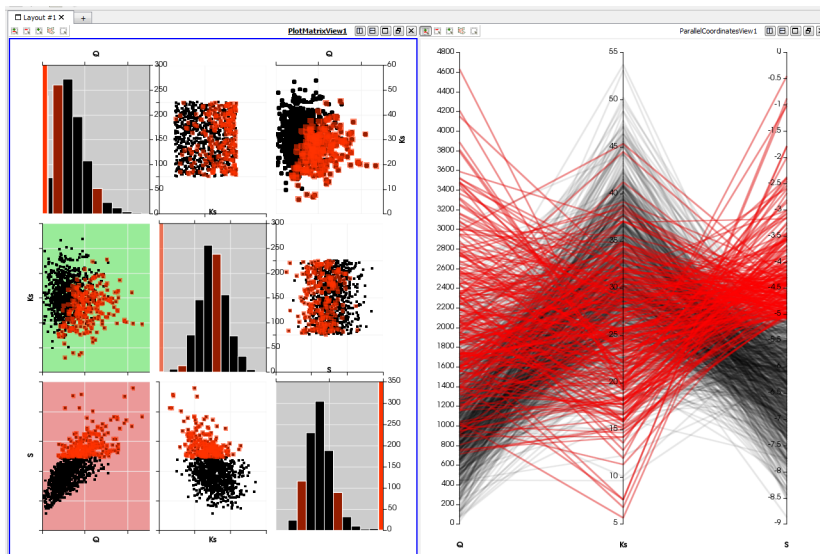


# PERSALYS: 1D fields

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

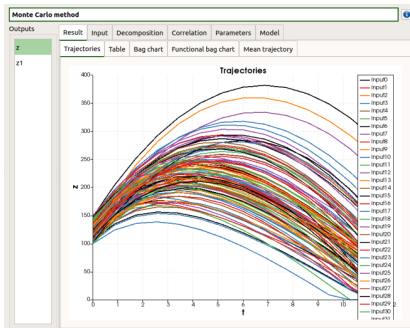
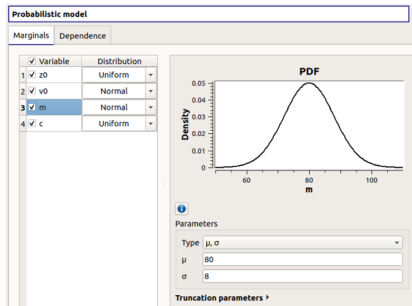


# Interactive uncertainty visualization with Paraview



# 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.

