mirrhia

ENVIRONMENTAL MONITORING SYSTEM



Mirrhia 2 - Calibration module guide

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1. Modification history

Revision Date	Modified sections	Modification/description	Author
08 JAN 2025 Rev 1.0	All	Document creation	Kevin Piette
26 AUG 2025 Rev 1.1	5.1.3	MB-6010: Fix image display	Cyril ACQUISTO

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2. Purpose and scope of this guide

2.1. Background

The calibration module allows a user to manage a highly configurable calibration process within Mirrhia, choosing any probes from the system as the calibrated ones and benchmark ones, monitor its progress and export or apply the results.

2.2. Application

This guide applies to Mirrhia 2.5 and above, and will introduce the calibration module and how to use it, from the preparation and configuration of calibrated and benchmark probes, to the process itself, and then the viewing, export and application of the results.



Activation and use of Mirrhia's Calibration Module is subject to licence requirements. This feature is only available with the purchace of the calibration module licence.



Mirrhia Web, Mirrhia Hub & RabbitMQ services must be running to ensure the acquisition.

3. Permissions

The permissions associated with this module are as follows:

Permission name	Description
RetrieveCalibrationCampaigns	Allows the user to access the module in readonly mode. This permission will make the module visible in the menu.
ManageCalibrationCampaigns	Give the write access to the user.

Note: These permissions are only available if the module is activated.

4. Definitions

4.1. Probe calibration

Probe calibration is an essential and recurring exercise to guarantee and certify measurement accuracy during their use.

Calibration involves placing the probes to be calibrated, together with a standard probe, in the same environment for a given period of time. After a measurement stabilization phase, a series of sample measurements are taken simultaneously on the probes. On the basis of the recorded data, the deviation and standard deviation are determined in order to calculate the correction factors to be applied to the probes. Calibration ends when the calibration certificate is generated for the probe.

With the calibration module, you can create campaigns to calibrate one or several probes. At the end of a campaign, you'll be able to export or apply the resulting certificate.

4.2. Types

There are two types of certification :

- **Calibration**: A procedure used to (re)calculate the uncertainty of a probe. Obtained by comparing measurements with a benchmark probe, taking into account any correction factors already applied to the probe. It can be processed in one or more *stages*. In the case of multiple stages calibration, the results of the various stages are combined and averaged. In the field, probes are calibrated on a regular basis (e.g. every year).
- **Adjustment**: A procedure for (re)calculating a probe's correction polynomial. Obtained by comparing measurements with a benchmark probe, taking into account the probe's original (uncorrected) measurement. If the probe has already been used officially, an adjustment should only be carried out after a calibration of the probe has been carried out which shows excessive drift. Once the polynomial has been calculated, the uncertainty is recalculated over 1 step, taking into account the new polynomial. An adjustment requires at least 3 steps. In the field, an adjustment is carried out either on a new probe or on a probe whose uncertainty is too high. Adjustment is therefore almost always preceded by calibration. For an n-step adjustment:
  - The first n-1 steps are used to calculate a correction polynomial of degree n-2.
  - The last step is used to re-calculate the uncertainty, taking into account the new polynomial.

4.3. Steps

Each campaign is defined, among other things, by a number of so-called **steps**.

A step is a part of the calibration or adjustment procedure which consists in taking several

measurement points (usually 5) with a standard probe and at least one probe to be calibrated, aiming at a given setpoint. The values measured for each sensor are used to calculate a polynomial or uncertainty.

In practice, a step is a target value for the probes to reach and begin their stabilization, followed by the sampling phases. A campaign is considered finished and complete once each of its steps has been completed.

Computations of the results will occur after a completed (not cancelled) campaign.

4.4. Polynomial computation

To calculate a correction polynomial of degree *n*, *n+1* points are required. To obtain these points, we select *n+1* steps and, for each of these steps, we calculate the average of the values for the standard sensor and the sensor to be adjusted.

The polynomial can then be calculated by solving a system of equations with *n+1* unknowns.

Correction polynomial:

$$p(x) = a_n x^n + a_{n-1} x^{n-1} + \cdots + a_2 x^2 + a_1 x + a_0 .$$

$$p(x_j) = y_j$$

Equations system:

$$\begin{bmatrix} x_0^n & x_0^{n-1} & x_0^{n-2} & \dots & x_0 & 1 \\ x_1^n & x_1^{n-1} & x_1^{n-2} & \dots & x_1 & 1 \\ \vdots & \vdots & \vdots & & \vdots & \vdots \\ x_n^n & x_n^{n-1} & x_n^{n-2} & \dots & x_n & 1 \end{bmatrix} \begin{bmatrix} a_n \\ a_{n-1} \\ \vdots \\ a_0 \end{bmatrix} = \begin{bmatrix} y_0 \\ y_1 \\ \vdots \\ y_n \end{bmatrix}.$$

In the system shown above, we solve the system to find the unknowns (= the coefficients of the polynomial) represented by the **a**'s. The **x**'s represent the values of the sensor to be adjusted for the various stages. The **y**'s represent the values of the standard sensor for the various stages.

4.5. Uncertainty computation

In the case of an adjustment, the uncertainty is calculated on the last step, taking into account a new polynomial on the sensor to be calibrated.

In the case of calibration, the uncertainty is calculated for each step. The values calculated for each step are then combined to calculate their average.

1. For each step, the average difference between the sensor to be calibrated and the standard

sensor is calculated. In the case of adjustment, the new polynomial is applied to the values of the sensor to be calibrated.

2. For each step, the standard deviation of the difference between the sensor to be calibrated and the standard sensor is estimated. In the case of adjustment, the new polynomial is applied to the values of the sensor to be calibrated.
3. If several steps are used to calculate uncertainty, the results obtained at point 1 are averaged (d in the table below). The same applies to the results calculated at point 2 (s in the table below).
4. The uncertainties are then calculated (see table below). The final certificate contains either the global uncertainty or the expanded uncertainty AND the overall difference.

Name	Symbol	Description / formula
Global deviation	d	See point 3
Standard deviation	s	See point 3
Method uncertainty	m	Provided by the person in charge of the calibration
Expension factor	k	We're using 2
Type uncertainty	t	$\sqrt{m^2+s^2}$
Expanded uncertainty	u	k*t
Global uncertainty	g	$u+\lvert d \rvert$

4.6. Sequence of a campaign

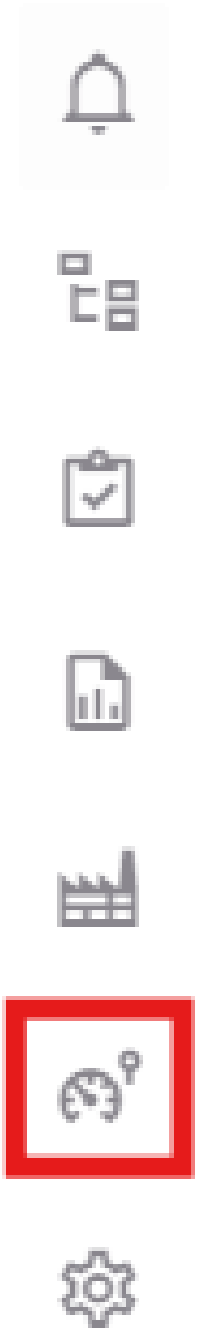
A campaign process is defined as follows:

- **Settings**: User set up the campaign by filling up required information as the concerned probes, the number of steps (value targets), timing related settings, etc.
- **Steps**: Once started, each step will be divided in 2 phases
  - **Preparation**: A pause period to allow the user to set up the equipments (ie, placing the probes in an oil bath)
  - **Process**: An automated process that implies, for each probe
    - **Stabilisation**: Period during which a probe must maintain its value to be considered stable
    - **Sampling**: Period during which reference data value are taken
- **Computations**: After steps are completed, results are computed based on the data taken during sampling
- **Results**: The user can view / export / apply the results for each calibrated probe

5. Instructions

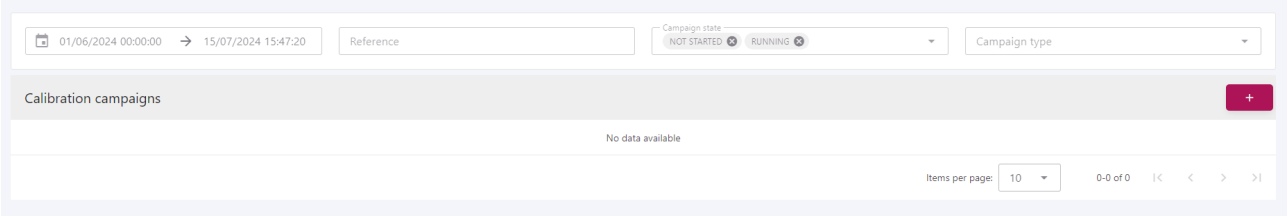
5.1. List campaigns

The campaigns listing is the first screen you'll see by entering the calibration module. The calibration module itself can be accessed by clicking on the calibration button of the main menu.



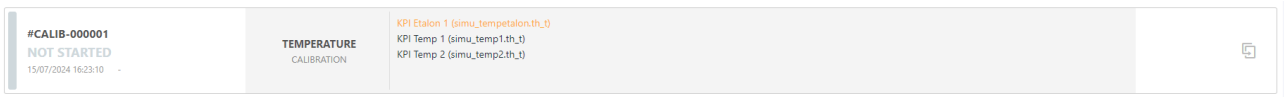
The user must have the adequate permission to see this menu

Campaigns screen will show the user the list of the calibration campaigns.
Campaigns are presented in a paginated data grid.



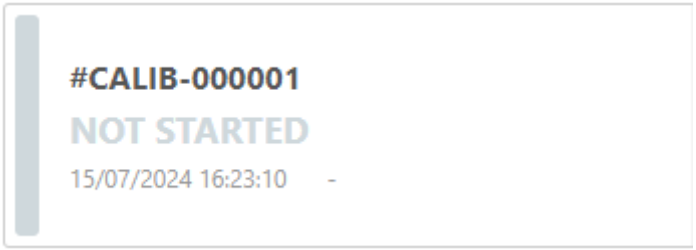
5.1.1. Campaign info

Each item of the list is presented to be visually usefully.

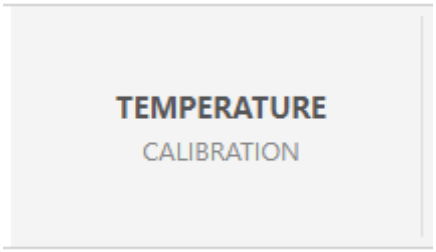


It’s fractionated into 4 areas:

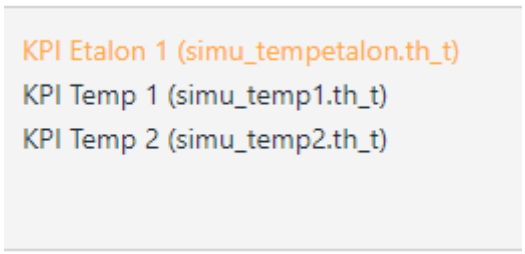
- The first area has the calibration reference name, the state, the dates of creation and end of the process, with a colored bar accordingly to the state



- The type of measure of the calibrated probe and the type of the campaign



- The list of the probe used in the campaign, with the benchmark colored in orange



- The available actions associated to the campaign (currently "copy this campaign to create

another")



Campaigns states (and corresponding colors) are not refreshed in realtime, user must perform a request or page refresh to do so

5.1.2. Filters

Items are filters with default values, to not show all the campaigns at once and load too much data.

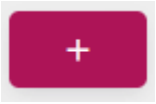
- Date range is last month by default
- Only ongoing campaigns are displayed, finished ones (completed and cancelled by user or by error) are hidden by default.

Items are sorted by creation date in descending order, meaning the last one are in top of the results.

5.1.3. Managing campaigns

In this screen, the user has access to various basic editing functions, including:

- Adding a campaign, by clicking to the "+" button on the top of the datagrid



- To edit/view a campaign, user has to click on a row of the grid
- To add a campaign by copying the settings of an existing one, user has to click on the "duplicate" icon button of the model campaign's row



- Filters are applied automatically when their values are updated

User must have the proper rights to see the **Add** and **Copy** buttons.

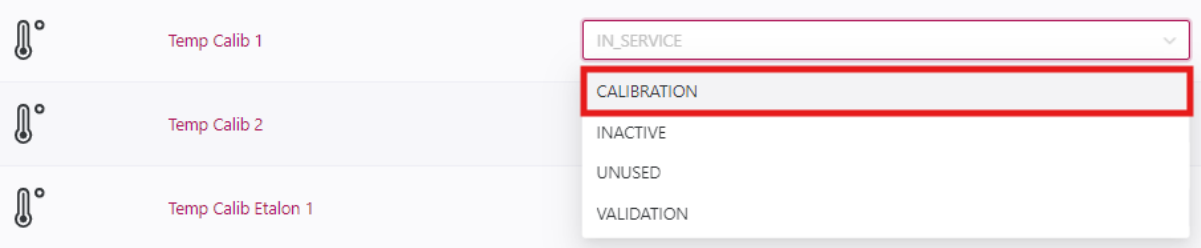
5.2. Campaign process

5.2.1. Preparation

To be able to use some nodes and their associated measure in a calibration campaign (as

calibrated probes or benchmarks), you must first set their mode to the status **CALIBRATION**.

To do so, go to the **Measure Management** screen, search for the wanted node(s), and switch their **Operation mode**.



If you don't do this, probes will not show up for selection in the calibration campaign settings screen.

5.2.2. Create a campaign

Like said in the Managing campaigns chapter, you have two choices to create a campaign:

- Create a brand new one by clicking the **Add** button.

This will create a new campaign for which you will have to fill every setting.

- Create a new one by copying the settings from another campaign.

This will create a new campaign, but most of the settings will be pre-filled.

Once created, user will be redirected to the campaign details screen.

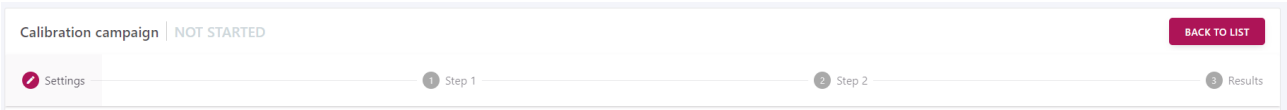
5.2.3. View or edit campaign

To view or edit an existing campaign, simply click on any row of the campaign list.

5.2.4. Campaign details

After creating a campaign, or by editing an existing one, the user will be redirected to the campaign details screen.

The campaign details screen is basically a "wizard"-like component with different tabs and associated views for each of its step.



- First tab is the settings panel
- N tabs will correspond to the N configured steps (in this example, there is 2 steps)
- Last tab is the results, that will only be available after a completed and success campaign

Notes :

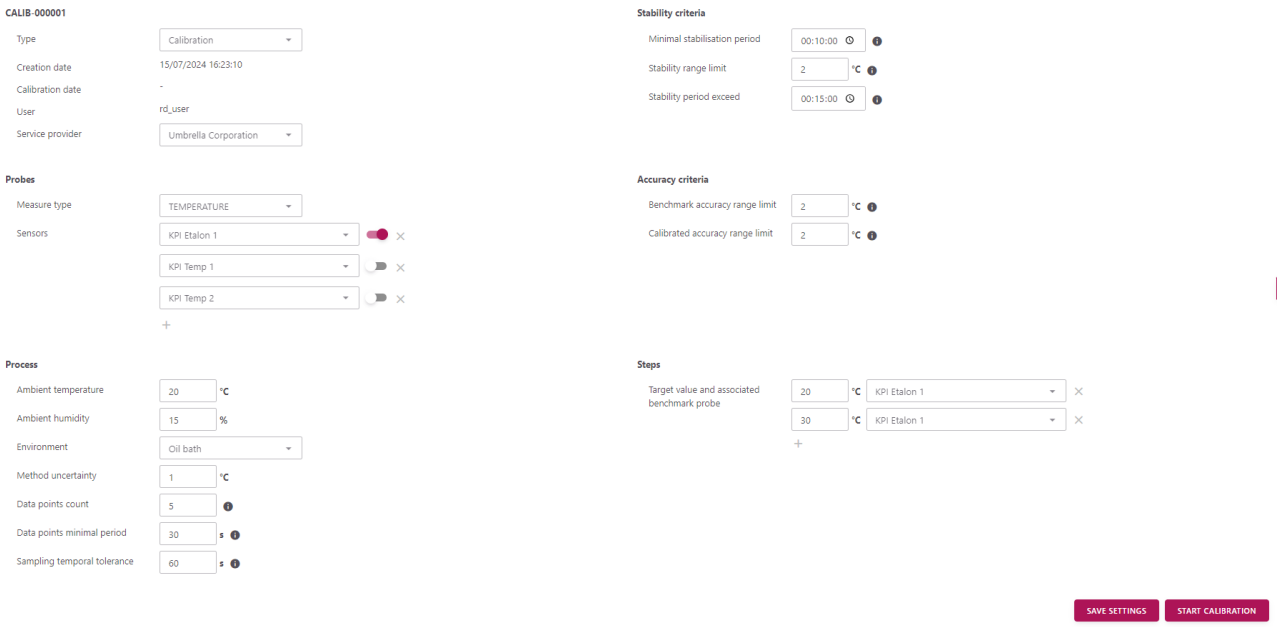
- Only the current step tab will be available during the process
- The steps will not be available anymore after the campaign process end
- Settings is the only tab that is always available during any state

5.2.5. Set up a campaign

Campaign settings screen can be reached by opening / editing any campaigns, or creating a new one.

- Campaign settings view is part of a "details screen" presented as a wizard with several steps, settings being the first one
- Campaign settings is the default view when creating campaign or viewing / editing a non-running campaign
- Settings will still be available by clicking on the corresponding tab, even if the campaign is running or completed

Settings screen is basically a large form with all the parameters of the campaign.



All values are mandatory, and will be showed as invalid if not assigned to a value, even the one that are just informative (i.e. ambient infos like temperature or ambient humidity)

Settings list:

Type	Type of the campaign, can be "Calibration" or "Adjustment"

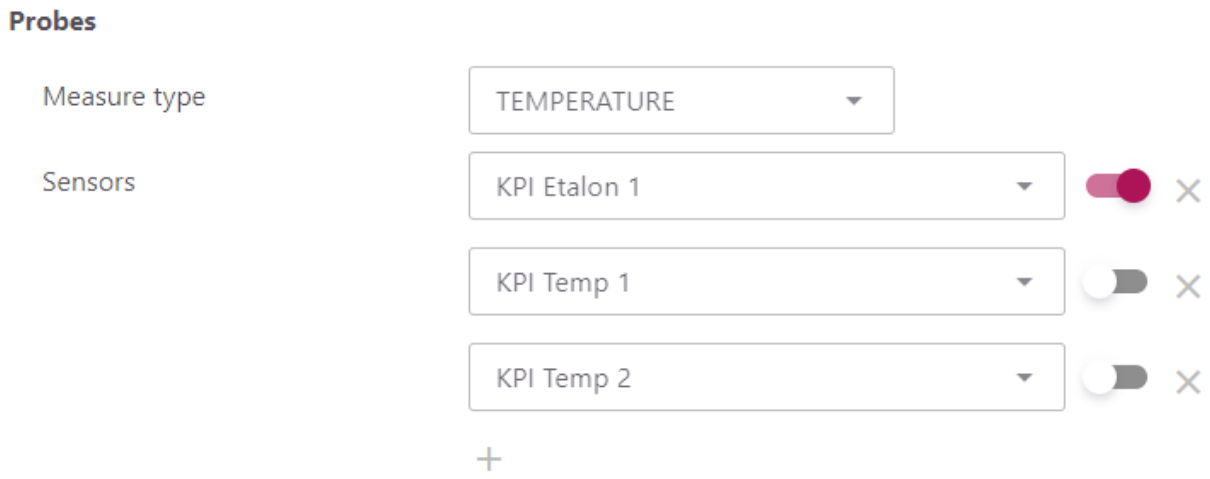
Creation date	The datetime of the creation of the campaign, autofilled when campaign is created
Calibration date	The datetime of the end of the campaign, autofilled when campaign process is finished
User	The user that created the campaign
Service provider	The company in charge of the campaign
Measure type	The measure type of the probes that will be used in the campaign
Probes	The listing of the probes (sampling node corresponding to Measure Type and in "Calibration" mode) that will be used in the campaign. Some of them can be marked as benchmark.
Ambient temperature	The ambient temperature of the (physical) room where the campaign will be performed
Ambient humidity	The ambient temperature of the (physical) room where the campaign will be performed
Environment	The environment where the probes will be emerged
Method uncertainty	The method uncertainty used for results computations. It is the uncertainty caused by the limitations or variability of the measurement method, including biases, calibration errors, or technique imperfections.
Data points count	The number of reference samplings to make for each steps of the campaign
Data points minimal period	The minimal time interval between two data points
Sampling temporal tolerance	The maximal time interval between a sample from a calibrated probe and the one from the benchmark one
Minimal stabilisation period	The minimal time period before considering the probe stabilization phase
Stability range limit	The maximum rang limit for a value (- value < target < + value) to be considered for stabilization.
Stability period exceed	The maximum delay to wait before stopping the process if no stabilization occurs.
Benchmark accuracy range limit	The maximal value interval (- value < target < + value) to consider a point valid for the benchmark probe (target is step value)
Calibrated accuracy range limit	The maximal value interval (- value < target < + value) to consider a point valid for the calibrated probe (target is benchmark value)
Steps	The list of the steps for the campaign (the step is a value for the probes to target) with the associated benchmark



These settings become readonly when the campaign is started or finished. You can only edit those parameters when the campaign is not started yet.

Probes and **steps** are dynamic lists, meaning that you can add / remove items as you wish. (within the limits of consistency, of course)

- To add a probe, just click on the "+" button, that will create a new line where you can select a probe, flag it (or not) as benchmark with the switch.



- To remove a probe, click on the "X" button next to the line you want to remove
- You can only add probes after having selected a measure type, to have corresponding data in the node selector, otherwise the list will be empty
  - Note that only the node in mode CALIBRATION will be populated in the list
- In consequence of this, updating a measure type after having set some probes will reset them
- You can add or remove a step with the same logic as probes, each line will allow you to set
  - The target value for the step
  - The associated benchmark for the step



- Yon can only add steps after having added probes, and marked one or several of them as benchmarks, otherwise the benchmarks list for the given step will be empty
- In consequence of this, updating a measure type after having set some steps will reset them (as the probes will be reset)

Once you are done with the settings, you can save the campaign by clicking the **Start calibration** button at the bottom of the screen.



This will enable the **Start calibration** button next to it, that will allow you to start the process.



Note that once the calibration started, you will not be able to change settings anymore.

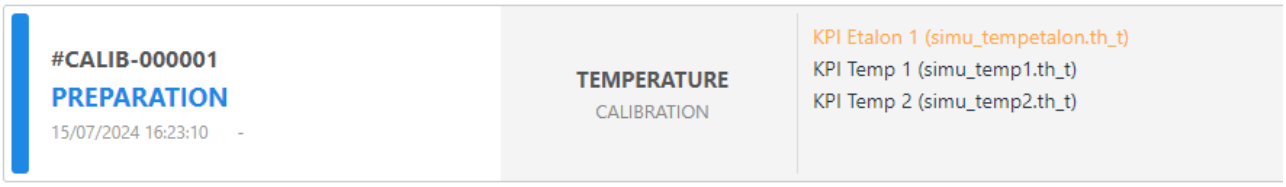
5.2.6. Start calibration

Once campaign settings have been validated and saved, the campaign process can be started by opening the campaign.

This will open the campaign details screen as usual, the start button will be available.



Once the campaign started, the details screen will automatically update itself to visualize the new state.



5.2.7. Calibration steps

When a campaign process is in progress, the user is able to visualize the concrete progression. By opening any running campaign, or just after a campaign has been started, the details screen will automatically place itself on the corresponding current step.

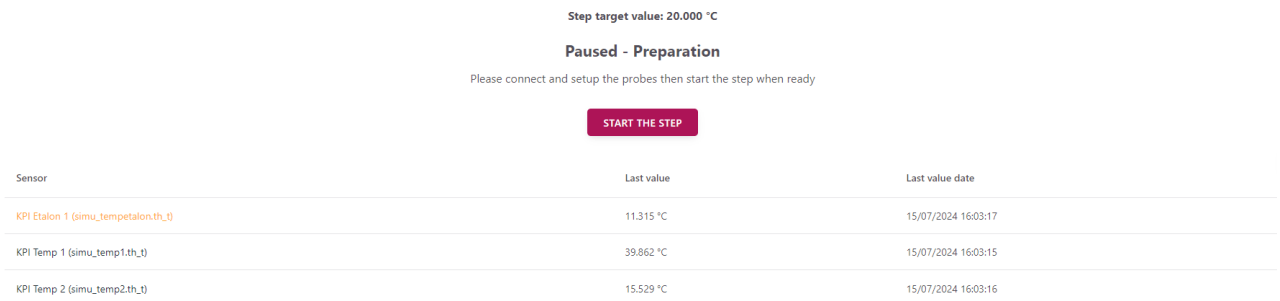


The settings screen will always be accessible by directly clicking on its associated tab.

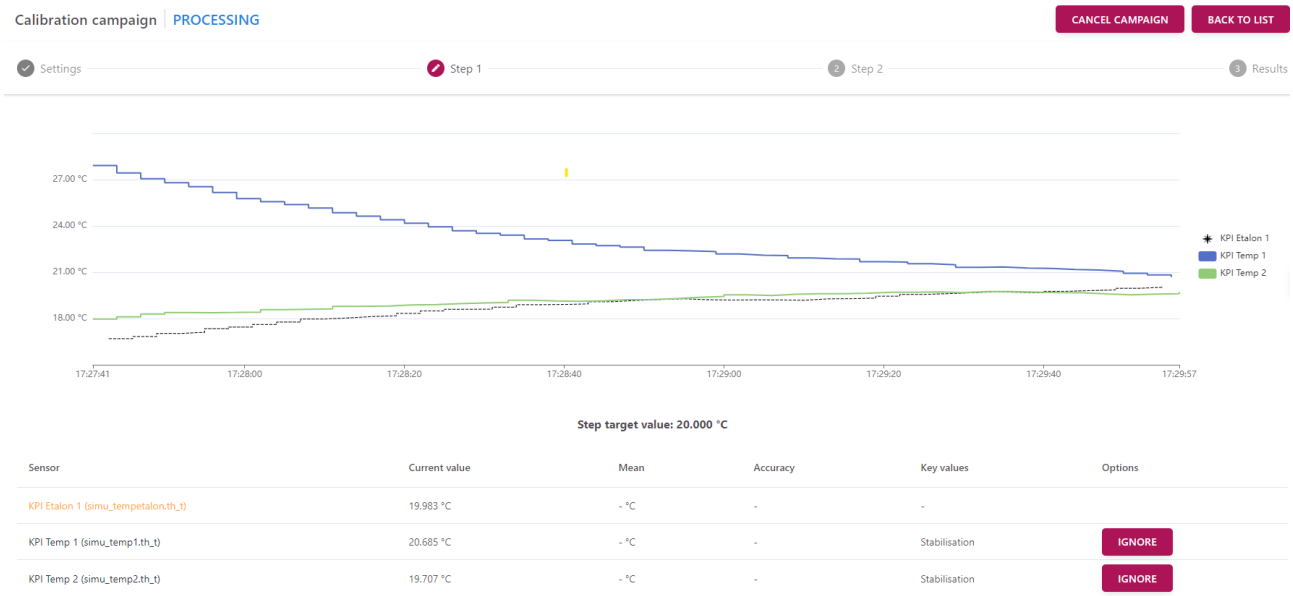
Each step tab/view of step is divided in 2 views that will show up accordingly to the step status

- Step isn't started yet: view is **preparation** one, the managing user is invited to set up the equipments (i.e., emerging the probes in the oil bath)

- In this case, the step/view will be maintained as long as needed by the operator, he's the one that validates it (by starting the step)
- In this view, the user can see in realtime **the data of the probes**, and the **target value** needed for the step



- Step is started: view is "step data view"
  - In this case, the step/view will automatically end when the all the needed data points have been sampled or an error occurred (i.e. max period time elapsed).
  - In this view, the user can see in realtime the data of the probes, the corresponding graphical representation.



This part of the process is automated, and completes automatically after the following events:

- The probes have stabilized (reached and maintained the target value) and remained within the limit values for a certain time
- The benchmark probe has stabilized, the calibrated probes also go into stabilization, relative to the value of the benchmark one
- Once calibrated probes stabilized, sampling is launched and big "dots" appear on the graph representing the key values. (key values are also listed in the data information below the graph)



The datagrid will also show some usefully information:

Sensor	The name of the sensors (benchmark ones will be in orange). They are also present in the graph's legend.
Current value	The current value
Mean	The mean of the key values (will be not set if no current key values)
Accuracy	The accuracy of the key values. Will be OK if **all** the key values are valid, Not OK otherwise.
Key values	The key values taken in the sampling phase. In the stabilisation phase, the field will show "Stabilisation", or "Ignored" if the probe has been cancelled.
Options	Some action that the user with proper rights can do. (Cancel the probe)

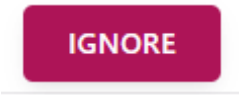
Data are refreshed every **10 seconds**.

Additional notes :

- A started step cannot be started again
- The view will be automatically set to the processing step when "opening" a campaign
- A step itself cannot be cancelled or ignored, but the entire campaign will.

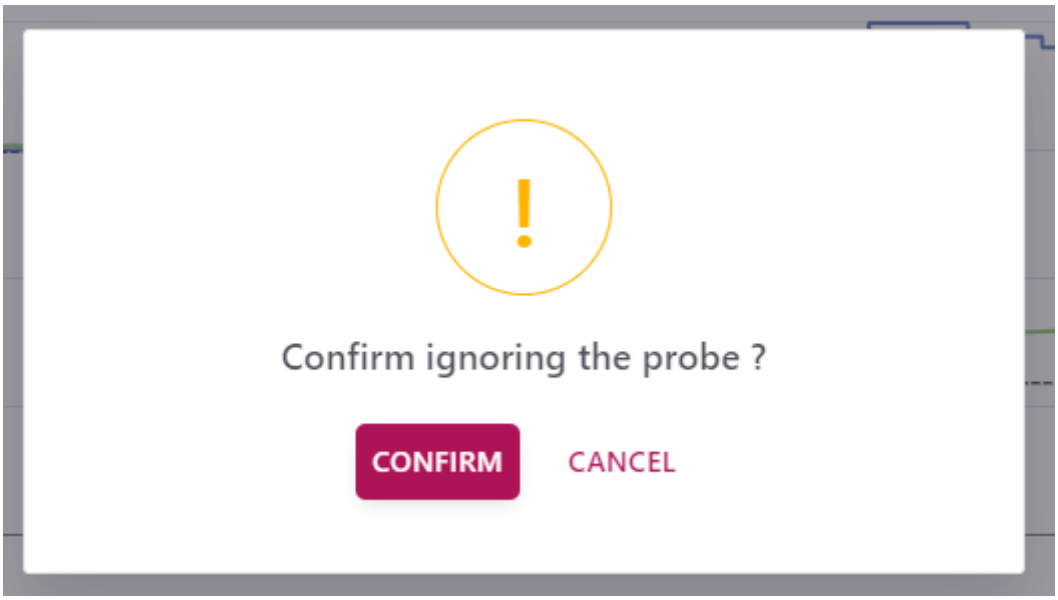
5.2.8. Canceling the calibration of a probe

When a step is processing, the user can "ignore" a probe (meaning cancel its individual process) by clicking the ignore button of the said probe in the details screen.

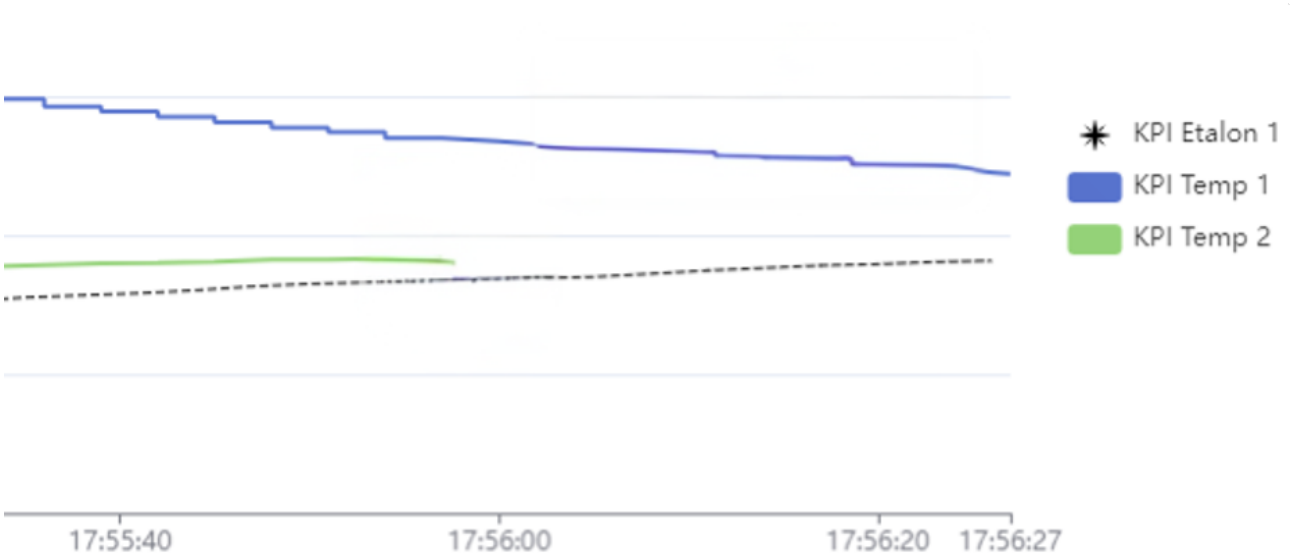


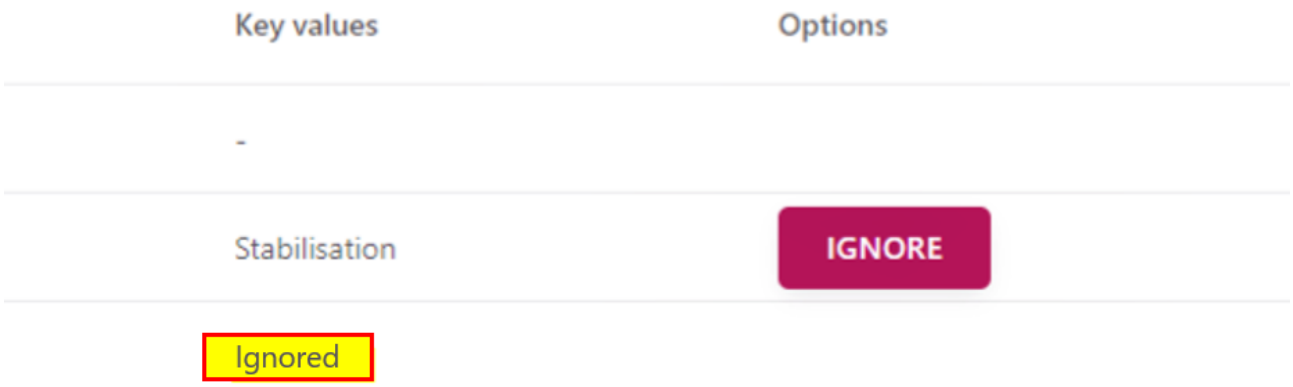
After ignore is validated, the probe will not be considered anymore and will be completely ignored till the very end of the process

- Ignoring a probe will prompt the user if he's sure to proceed



- Ignored probe will not be tracked anymore on the graph, nor its data showed
- The probe will be marked as **ignored**





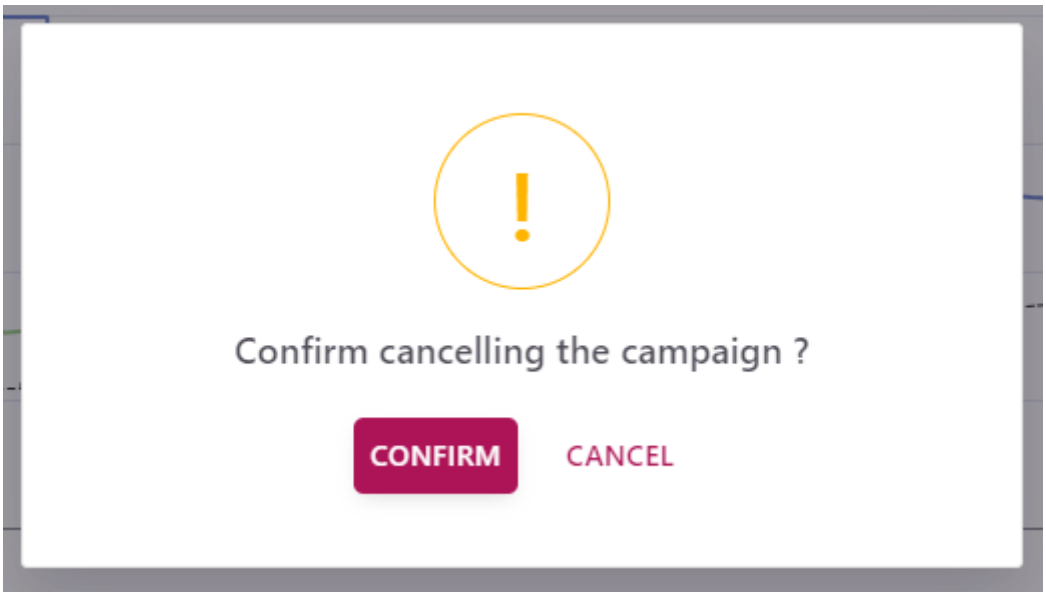
- The probe results will not be considered in the finals results
  - User will not be able to see said the results, as there will be empty

5.2.9. Canceling the campaign

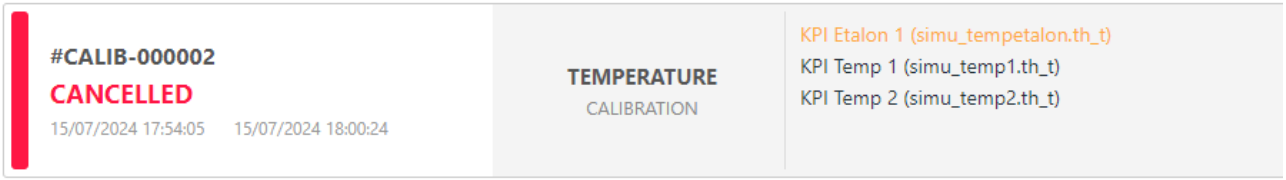
Campaigns can be cancelled any time during the running process (i.e. step in preparation or running step) by clicking the **Cancel campaign** button in top of the wizard in details screen of a campaign.



- Cancelling a campaign will prompt the user if he's sure to proceed



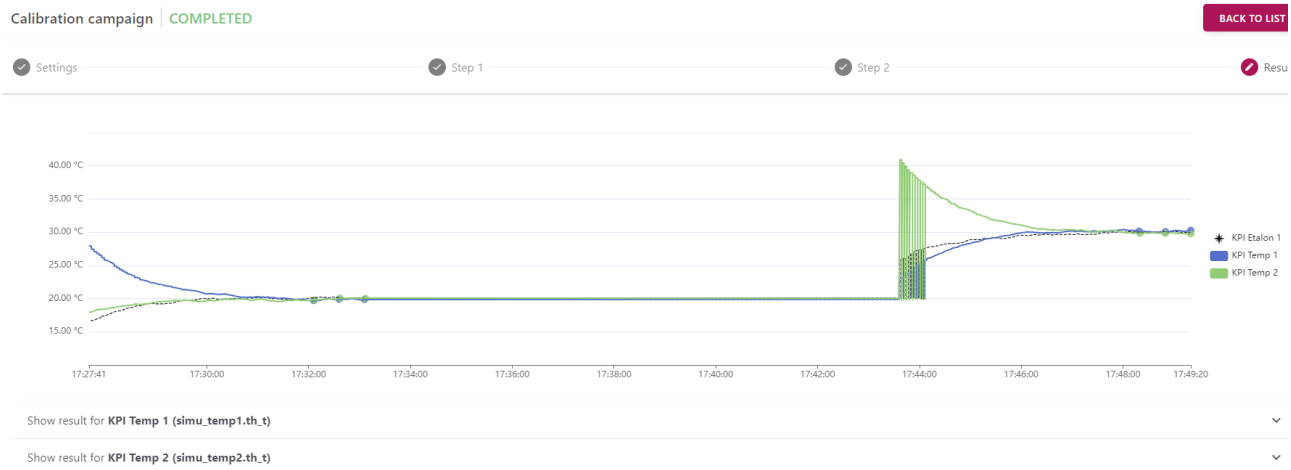
- Cancelled campaign will be showed as such in the campaign list



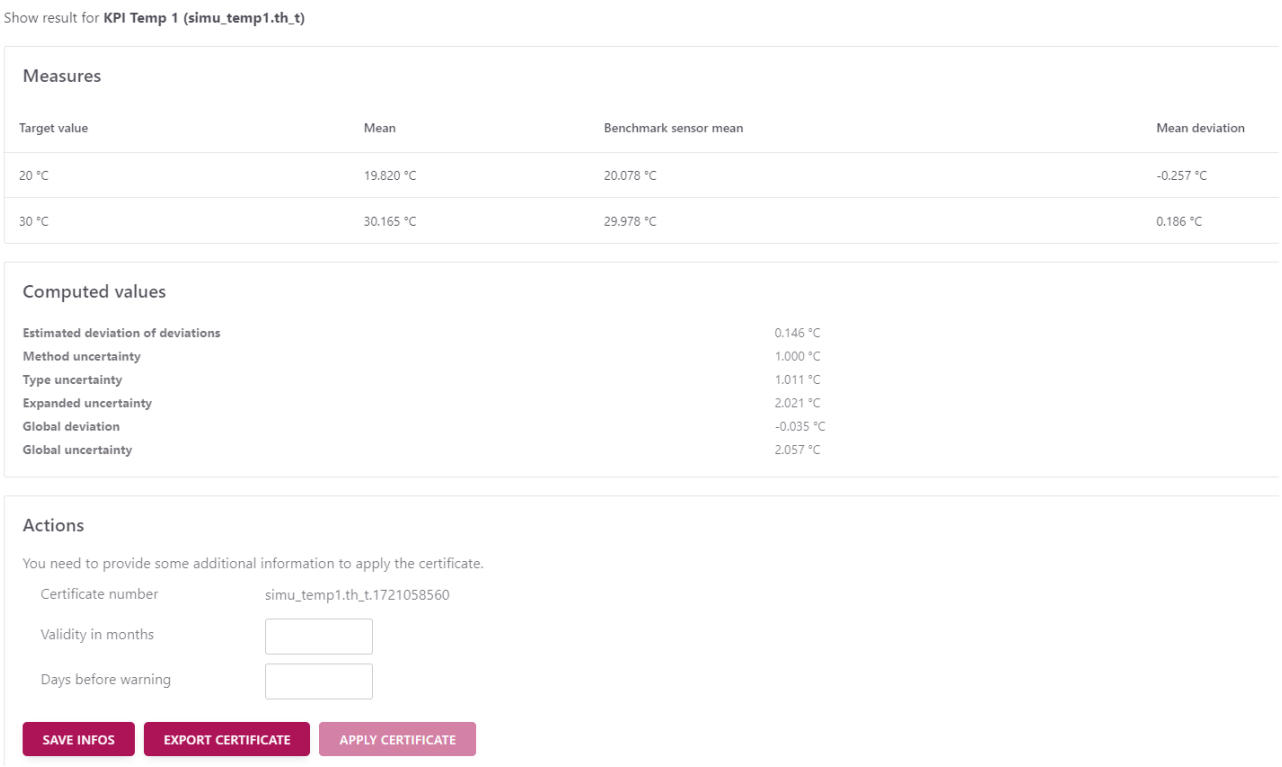
- Cancelled campaign can not be restarted anymore (creating a new one is mandatory)
- Results panel will not be reachable, as there are no results

5.2.10. Campaign results

After a successfully completed campaign, the user can reach the result screen by opening the said campaign (or automatically after the last step).



- Each calibrated probe has its own corresponding result view that can be expanded





an ignored probe during the process (manually or automatically after an error) will be marked as **Ignored** and will not be expandable, as no results will be available.

First, a grid will show some data, for each step: * The step value * The mean of the probe * The mean of the associated benchmark probe * The computed mean deviation

These values will also be present in the exported certificate.

Above that, you'll find the different computed values (the actual results)

- The estimated deviation of deviations
- The method uncertainty
- The type uncertainty
- The expanded uncertainty
- The global deviation
- The global uncertainty

These values will also be present in the exported certificate.

Finally, the **Actions** panel that allows you to:

- Export certificate in PDF format
- Apply the certificate to the node associated with the measure
    - This action will only be available if you provide some additional information, like the

validity in months and the **days before warning**, like you would do in the **node details screen**.

5.2.11. Export certificate

After a successfully completed campaign, a corresponding probe results can be exported in a calibration certificate in PDF format.

- Each calibrated probe has its own corresponding certificate ready to be exported
- First export will take longer time as it'll be actually generated and stored to database
- The later exports will take advantage of the stored version and will be significantly faster



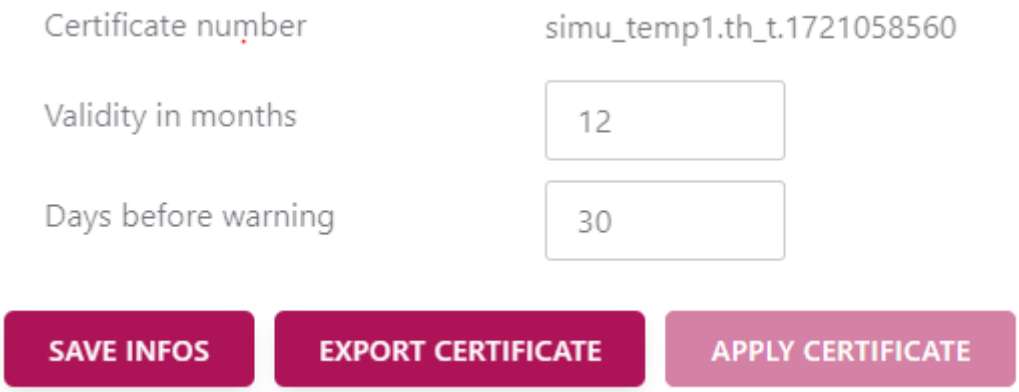
5.2.12. Apply certificate

After a successfully completed campaign, a corresponding probe results can be directly applied on the linked node.



The certificate will be applied on the **current** linked node and then not necessarily the same as the one the measure was linked during calibration.

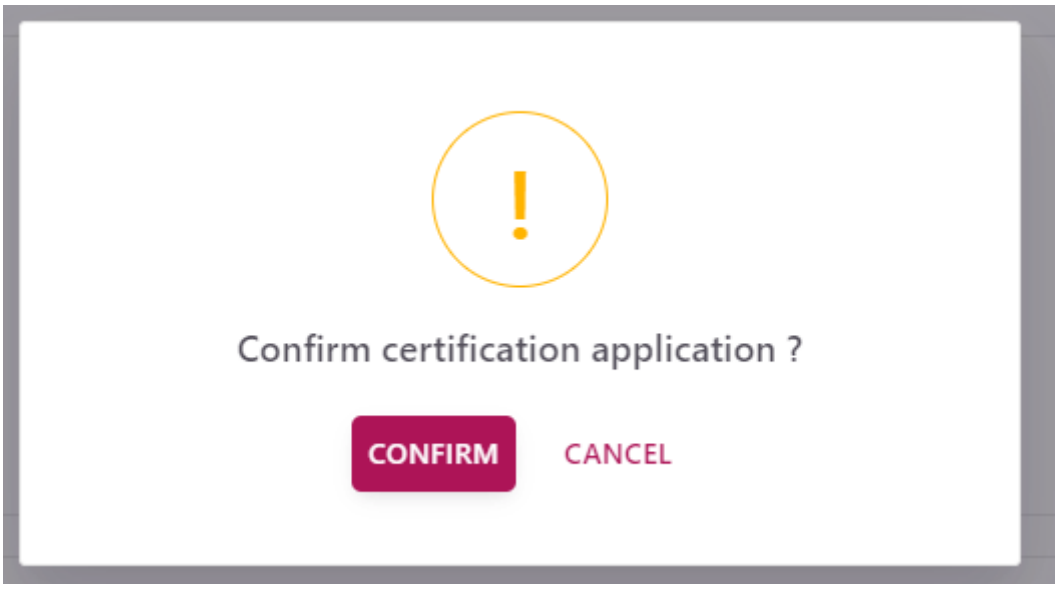
- This action will only be available if you provide some additional information, like the **validity in months** and the **days before warning**, like you would do in the **node details screen**.



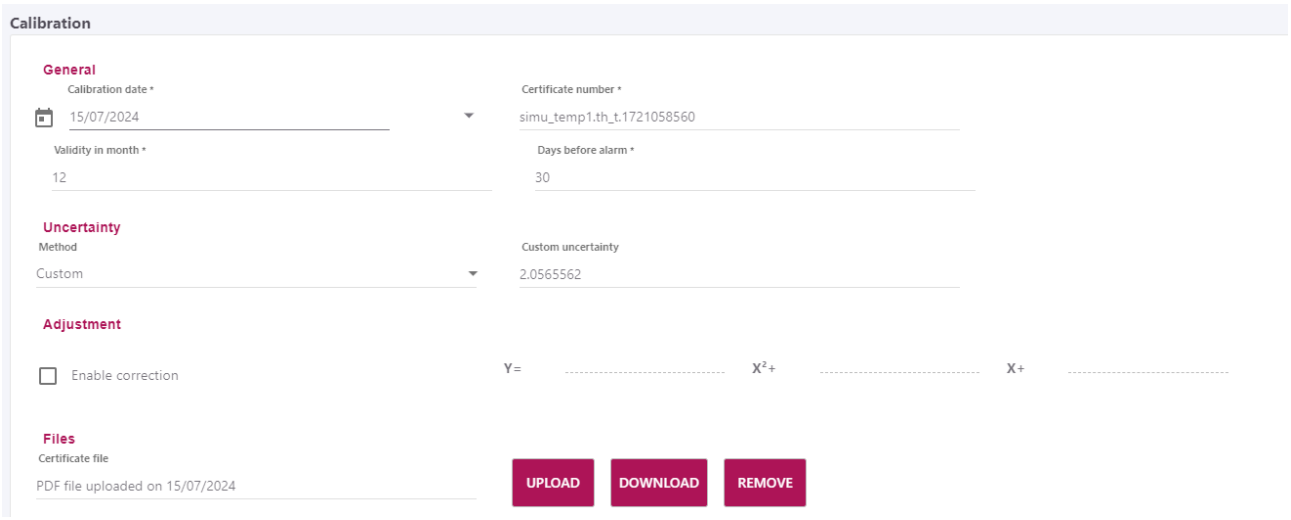
Once saved, the **Apply certificate** button will be enabled



A confirmation will be prompt to the user



Once applied, you can see the certificate information associated with the node, in the **node details screens**



You'll be able to export the certificate in PDF format directly from this view by clicking on the **Download** button, in the **Files** section.



Remove the PDF from the node (by clicking on the **Remove** button) will not delete the said file (it will be always available from the corresponding campaign results screen), but only the association with it.