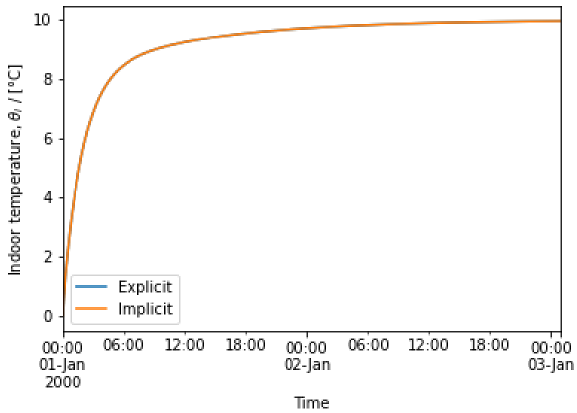
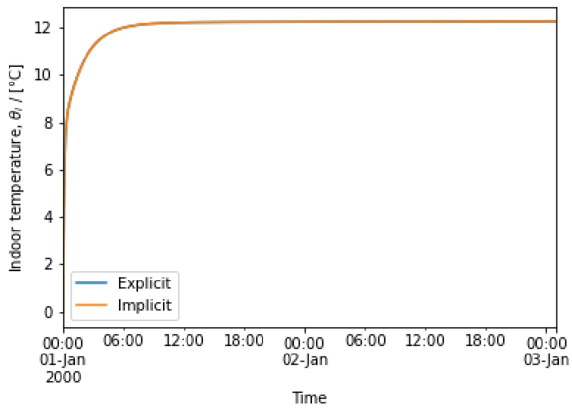
Toy Model House - G5

Initial model

The initial model, whose parameters are described in the code V0, gives the following results for the evolution of indoor temperature.





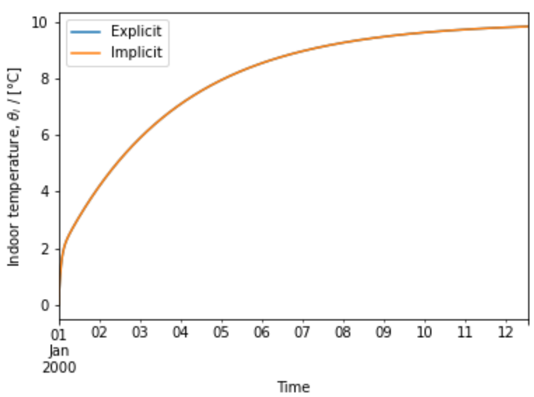
evolution of indoor temperature without and with internal loads

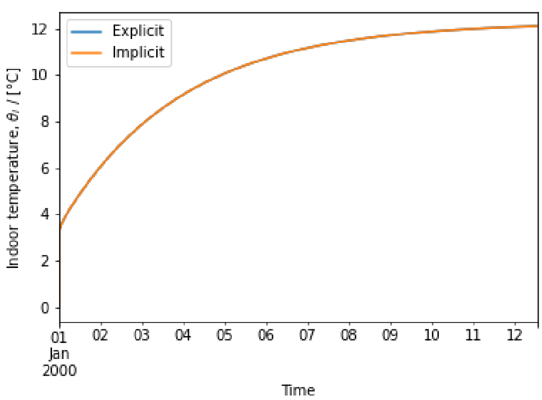
Settling time : 2.04 days
duration = 49.0 h

Variation 1 : external insulation

(see code variant1)

For this first variation, we chose to replace the internal insulation by an external insulation. We obtain the following results.





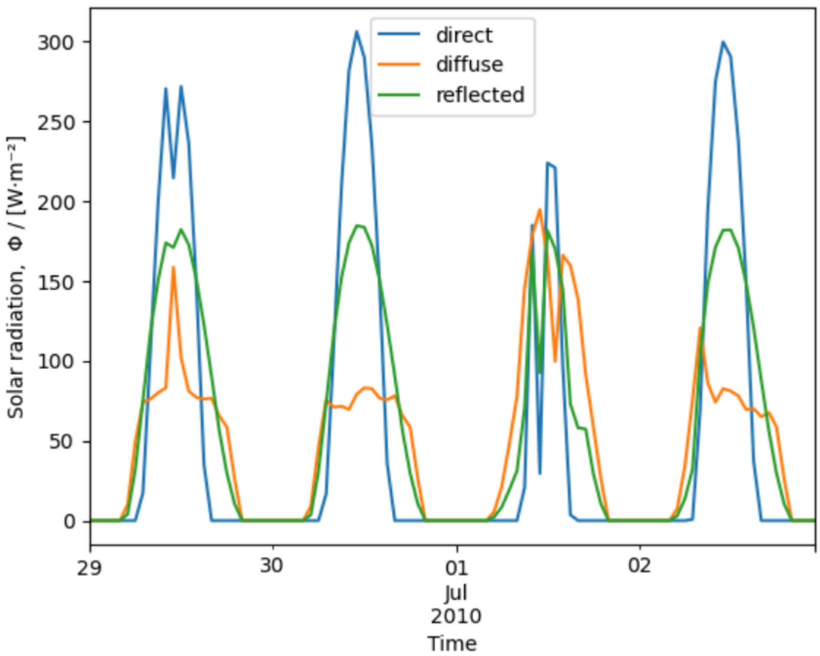
evolution of indoor temperature without and with internal loads

Settling time : 11.52 days
duration = 277.0 h

We can observe that compared to the initial model, the settling time is much longer : the steady-state with the internal insulation is reached after 2,04 days, whereas it is reached after 11,52 days with the external insulation.
The duration is also longer : 49h compared to 277h.

Variation 2 : influence of solar radiation

(see code : variant 2)
We are taking into account the solar radiation : ie. The absorption coefficients, the reflectivity and transmission of sun rays through the zone-toy house model. We split the radiation into 3 categories and we see that the part that has an impact on the zone is the direct radiation.



Variation 3 : modification of the width

To conduct the influence of the construction width onto the settling time, several modifications have been made. Firstly, the width of the concrete has been changed from 0,20 m to 0,25 m. In the following steps the insulation and glass width was duplicated to 0,16 m and 0,08 m and reversed.

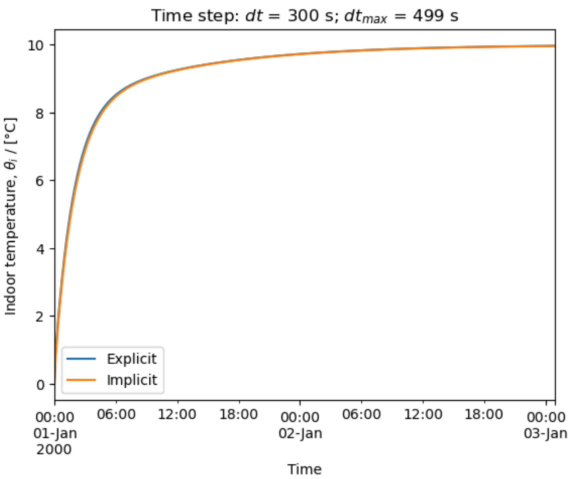
Scenario	Settling time	Difference
0,20 m concrete 0,08 m insulation 0,04 m glass	48,93 h	21,62

0,25 m concrete 0,08 m insulation 0,04 m glass	70,55 h	1,38
0,20 m concrete 0,16 m insulation 0,04 m glass	71,93 h	0,07
0,25 m concrete 0,16 m insulation 0,08 m glass	72,00 h	21,98
0,20 m concrete 0,16 m insulation 0,08 m glass	50,02 h	0,99
0,20 m concrete 0,08 m insulation 0,08 m glass	49,03 h	

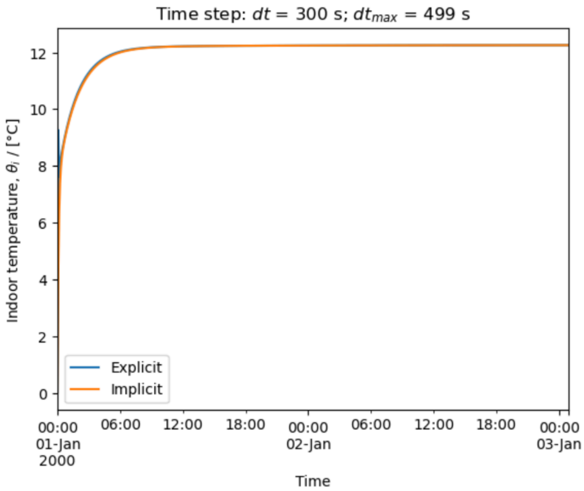
As visible in the table above, the change of the width of the concrete wall made the greatest difference in the settling time of the construction. The impact of the insulation and glass can be, in comparison to the concrete, neglected.

Variant 4 : No imposed time-step

The initial graphs are the following :



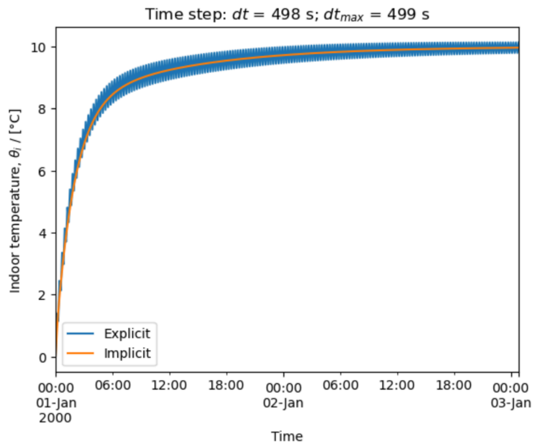
and with internal load, it changes to :

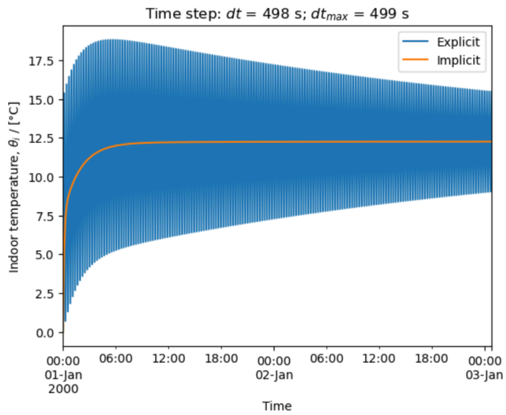


We can see that the explicit and implicit curves are almost superposed, with only a very small error (at the order of 10e-15). This means that when the system is being let free, it naturally goes to the set-point temperature with a time-step dt=300 seconds.

Variant 5 : Imposed time-step

In this version, we impose the time-step. Thus, by putting “True” in the time-set code line, we obtain the following graphs :

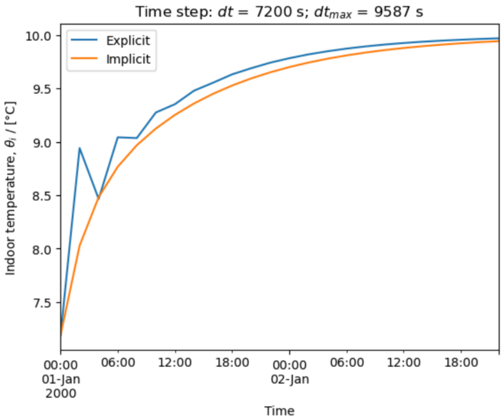


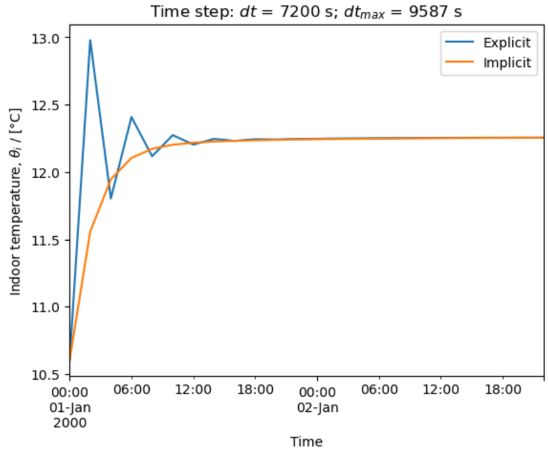


What we can say is that in this case, the explicit method is not accurate. Indeed, instead of creating a line, the points are all scattered, even though the global shape we obtain is alright. We also see that the time-step indeed changed from 300 to 498 seconds, as it was set. The fact that the time-step is bigger here “forces” the system to be less precise and that is why we observe these kinds of results.

Variant 6 : Neglecting air & glass capacities

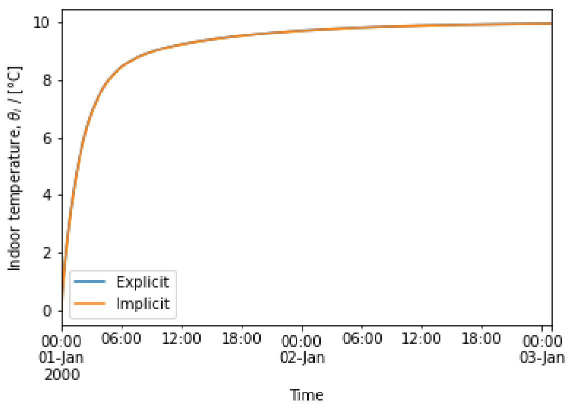
When neglecting both the air and glass capacities, we obtain the following graphs :

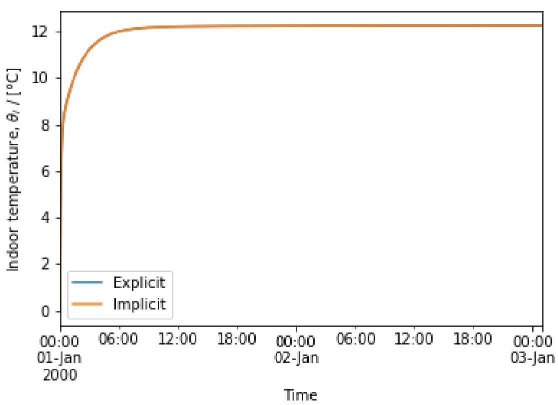




We can observe that the time-step has become really huge and the curves are more rounded, meaning that the system is struggling to reach the set-point temperatures. The explicit model is once again more scattered than the implicit model, which has a smoother curve. The stabilization thus depends on the capacities that we use for modeling the toy model house (here of air and glass). What this means is that it is easier to work without neglecting the capacities that surround the model house because the units change in order for the temperature in the model to set are being made by implementing all the parameters.

Variant 7 : Controller ineffective (0)





We are using no controller (Kp=0) which leads to a maximum time step of 8,31 minutes with a dt of 8 minutes. The settling time is 2,04 days (48,9 h) which leads to a duration time of 49 h. The output of the state-space representation (yss) is 10,0 °C. The error of the steady-state values obtained from the system of DAE settles around 8,88e-15°C. The value of the output of the state-space representation with an input of Q (yssQ) is 12,26°C.

Variant 8 : Perfect controller (infinity)

We changed the controller gain to the perfect controller (Kp=1e4). There we could see that the maximum time step changed to 0,11 minutes with a dt of 6,0 seconds. Even though the settling time changed to 2,02 days (48,6 h), the duration stayed at 49 h. In comparison to the version without a controller gain, the output of the state-space representation (yss) is 19,92°C. Also the error of the steady-state values obtained from the system of DAE changes, when the perfect controller is applied. Instead of the value of 8,88e-15°C from before, it switched to 3,55e-15°C. After the change to the perfect controller the value of the output of the state-space representation with an input of Q (yssQ) decreases to 0,10°C.