Benchmark tests for in-situ measurement evaluation methods.
- comparison of system identification methods – BESIM20

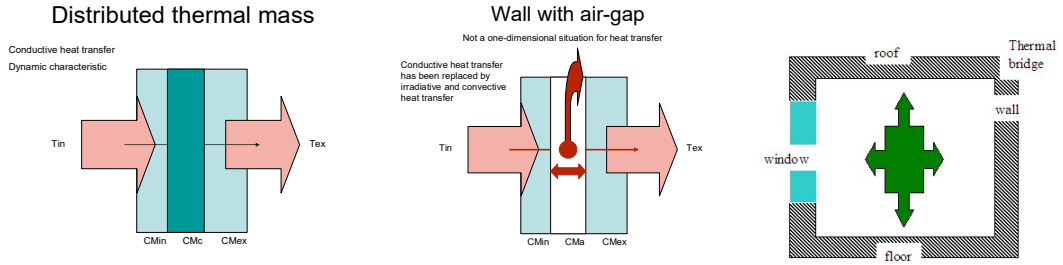
FINAL version, by Hans Bloem, 2 September 2020.

Objective: to evaluate dynamic calculation methods, e.g. the application of system identification techniques and to demonstrate the performance of different techniques applied to the analysis of experimental data from in-situ measurements of the heat transfer through a wall.

The approach considers three different type of "in-situ measurements":

1. Thermal transfer by conduction, e.g. through a solid wall component
2. Thermal transfer involving conduction, convection and radiation, e.g. an (air) gap wall that creates thermal convection and radiation exchange
3. Thermal transfer through a building envelope from indoor to outdoor environment, e.g. a whole building (impact of not measured thermal flows)

Details are presented in a dedicated report on in-situ measurement standards for buildings and building components.



This first part focuses on the thermal transfer by conduction, e.g. through a solid wall component.

A mathematical model represents reality however is always (by definition, a simplification of the true physical system. The user is responsible for defining the model and hence the simplification of it. There are ready to be used software tools that allow the development of a model and in some cases allows also to choose a specific method. In other cases the modelling environment is offered, such as MatLab, TRNSYS, LORD, CTSM-R etc. So there is enough freedom to choose from.
It is therefore that benchmark tests should reveal the ability of the final method and model to analyse data from in-situ measurements correctly, within defined uncertainty limits.

The data provided for these benchmark test can be considered for training as well.

A three step process in the application of one specific method (often user dependent) is proposed. At first instance the user can work towards the correct solution, since the model parameters are given (Case A). Second step is to demonstrate decision making in arriving at the best solution (Case B). And finaly the user should demonstrate the confidence in the result for a practical application (Case C; data will be given later).

Thermal transfer by conduction
The benchmark for the analysis of data from 1st type of in-situ measurements, e.g. by conduction, would consist of two exercises, describing a simple physical system (in this case a wall with two different temperature regimes on both sides and its resulting heat flow):

CASE A - based on simulated data with known parameters for the user.
objective: the method can be tested and one may demonstrate its performance.

CASE B - based on simulated data but the used parameters for generation are kept secret.
objective: the method should estimate the physical parameters and the accuracy of the estimates. The user should train the process of making a decision in model choice and hence reporting of the final result.

For both exercises, estimate the physical parameters R (thermal resistance) and C (thermal capacitance) and the standard error sR and sC. See definitions *defstatest.pdf*

The benchmark test describes also a template for reporting including the following requirements:

- report the results for all three exercises in a short paper (up to six pages of text and two pages of illustration)
- describing the methodology (model and method) and
- how the the results were obtained including the evaluation of uncertainty

Especialy the decision making part is important, such as analysis from residuals.

CASE A - Three layer symetrical wall. Data generated by applying the heat conduction equation.
A - 1 - noise free dataset
A - 2 - noisy dataset. Study the effect of filtering

CASE B - Data generated by an unknown (for the user) method (heat conduction equation, thermal network, ESP, TRNSYS, etc.). Parameters are kept secret.
B - 1 - noisy dataset
B - 2 - identify the minimum length to get a (fixed: 2%) accuracy

Fulfil the following requirements:

- report the results for both exercises in a short paper (up to six pages of text and two pages of illustration)
- describing the methodology (model and method) and
- how the the results were obtained including the evaluation of uncertainty

Especialy the decision making part is important, such as the analysis from residuals.

In the folder *BenchmarkTestDynMethods20* you should find the following files:

Besim20.pdf (this document) and *defstatest.pdf* (definitions and statistical tests)

in sub-folder **BDyn_CaseA**

DATA_A.TXT	A - 1 - noise free dataset
DATA_ANoise.TXT	A - 2 - noisy dataset. Study the effect of filtering
STAT_A.TXT	File containing statistics about supplied dataseries

in sub-folder **BDyn_CaseB**

DATA_BNoise.TXT	B - 2 - noisy dataset. Try to identify the minimum length to get a (fixed: 2%) accuracy. Demonstrate residual analysis
STAT_B.TXT	File containing statistics about supplied dataseries

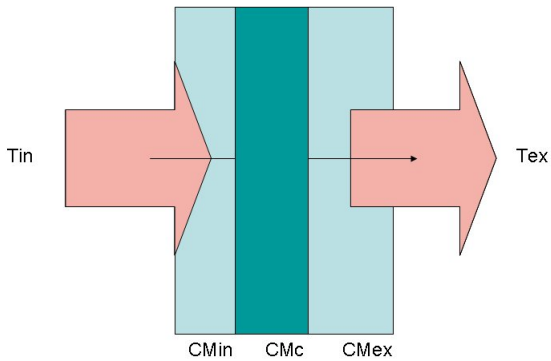
CASE A

Case A concerns a three-layer symmetric wall. The characteristics of the wall to generate the dataseries were:

Total R=2.54032 Km2/W C=16.65334 Wh/K m2

first layer	R=0.64516 Km2/W	C= 1920 J/Km2 (C=0.82667 Wh/K m2)
second layer	R=1.25 Km2/W	C=67500 J/Km2 (C=15 Wh/K m2)
third layer	R=0.64516 Km2/W	C= 1920 J/Km2 (C=0.82667 Wh/K m2)

Length of final data: 4 weeks (28 days 672 hours)



Resulting files : data_a.txt,stat_a.txt
Order of data : Texternal Tinternal Qinternal
Number of decimals : Tex 2, Tin 2, Q 3

Case A-1 length is 672 hours (DATA_A.TXT)

Case A-2 Applied noise:

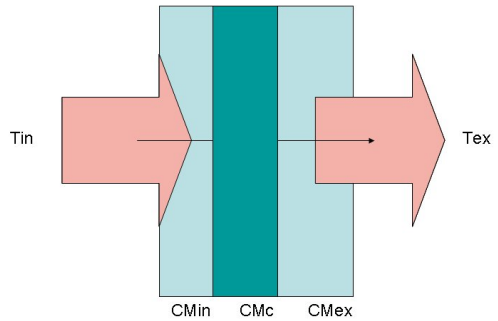
Data supplied (DATA_ANoise.TXT) in 4 decimals

See also STAT_A.TXT for statistics.

Case A	without noise			with noise		
	Tex	Tin	Qin	Tex	Tin	Qin
max	17.1000	21.7800	8.8810	17.6607	21.93828	9.044421
avg	5.6430	19.6440	5.5277	5.6348	19.63806	5.523809
min	-2.0000	17.2900	0.7100	-2.3487	16.82278	0.664535
var	13.9750	0.6750	2.1019	13.9554	0.748153	2.115947
length	672	672	672	672	672	672

CASE B

Case B concerns a three-layer symmetric wall. The characteristics of the wall to generate the dataseries were:



Length of final data: 25 days (600 hours)

Resulting files : data_bn.txt,stat_b.txt
Order of data : Texternal Tinternal Qinternal

Number of decimals : Tex 2, Tin 2, Q 3

Case B-1 data serie based on : length is 600 hours (original DATA_B.TXT; not supplied)

Data supplied (DATA_BNoise.TXT) in 4 decimals

See also STAT_B.TXT for statistics.

Case B	without noise			with noise		
	Tex	Tin	Qin	Tex	Tin	Qin
max	19.7000	22.8800	4.3080	19.7692	22.9526	4.3980
avg	13.8870	20.7190	2.3512	13.8995	20.7279	2.3549
min	7.8000	18.7200	0.2030	7.7547	18.4978	0.2753
var	4.5870	0.7600	0.7350	4.7686	0.8090	0.7429
length	600	600	600	600	600	600

NEXT STEP

In general, the assessment of the thermal resistance is straightforward, whereas the capacitance might give more problems for analysis. The organisers are in particular interested, to know the proposed solutions applied by the participants. Cases A and B (simulated data) should be considered as a preparation for the more complex Case C, for which data is derived from a well controlled **in-situ measurement**, in which solar radiation will appear. We wish you success and hope to receive many feedback.