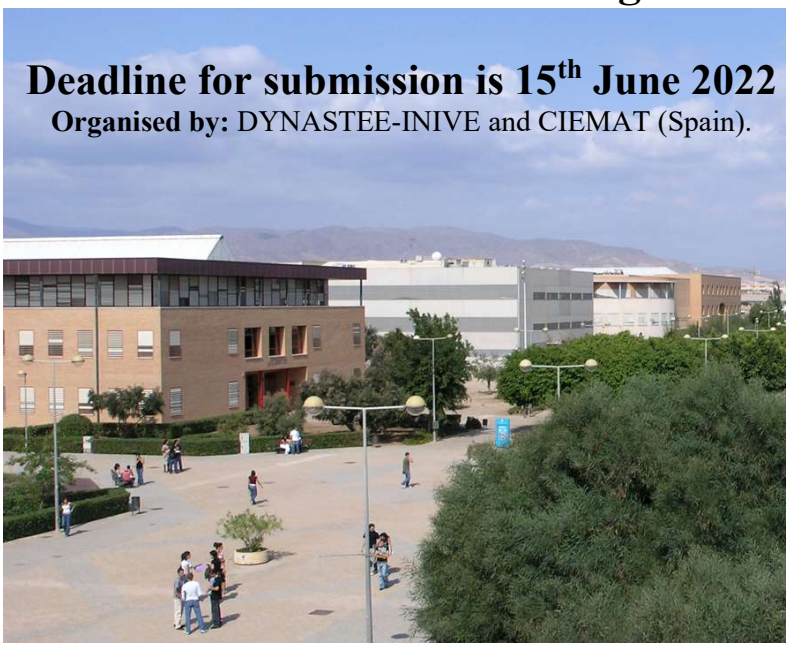
SUMMER SCHOOL 2022

7 – 14 SEPTEMBER 2022, Almeria, Spain

Towards whole building analysis from in-situ measurements and metering data



Lecturers: Hans Bloem (Dynastee), María José Jiménez (CIEMAT, ES), Peder Bacher (DTU, Lyngby, Denmark), Aitor Erkoreka, Irati Uriarte (University of the Basque Country, ES) and Richard Fitton (Salford University, UK).

The main purpose of this summer school is to train the students in a methodology for evaluation of *in-situ* measured and metering collected data. Many of the dynamic methods can be seen as techniques which bridge the gap between physical and statistical modelling. During the summer course, information on relevant software will be given and software tools will be used in the exercises. See also www.dynastee.info the document *Software techniques applied to thermal performance characteristics* some further information about methods and tools is given as well as on benchmark data for testing these methods.

Six enthusiastic lecturers will teach methodologies in >12 presentations (each 60 minutes) for assessing the heat transfer characteristics of building envelopes as well as whole building using benchmark data for hands-on exercises (12 slots of 90 minutes).

The cost for the six day-long Summer School is **500 Euro**. This covers:

- Handout of lecture notes and relevant papers.
- During lecture period Lunches and Coffee breaks.
- Social event and dinner during the weekend break.

Introduction

After 8 very successful editions of the Summer School on *"Dynamic methods for whole building energy assessment"* the organisers have decided to focus more on pragmatic application of these dynamic calculation techniques meaning that the analysis of building energy data is of high importance and can give potentially high value information to utility and end-user. The focus will be this time on increased complexity, several approaches and applied to benchmark data. Statistical methods for analysis of data collected from metering devices will be introduced as well.

Careful examination of energy consumption in the building sector, which is about 39% of the final energy consumption in EU-28 is needed in order to identify the specific areas for energy savings. Due to improved insulation levels of buildings this saving potential moves to more dynamic energy use sectors such as gains from appliances, high energy demand and consumer behaviour. Today, more and more data related to building and building components originate from outdoor testing under time-varying and dynamic conditions, or from real life use of buildings. Dynamic evaluation methods are techniques to analyse time series of data related to dynamic processes and to identify typical parameters of the physical processes for evaluation.

Among topics that will presented during the week-long Summer School will be:

- Data; first steps for evaluation by plots, graphical examination, common sense, average method and final data selection
- Correlation and statistics from the available data for model development
- Dynamic versus static analysis and physical versus statistical perspective
- General regression techniques
- Methods and models; Output error (OEM) and Prediction error (PEM) methods
- Residual analysis and feedback for model development
- LORD tool, MatLab and the R-routines in the R-environment
- Benchmark data-series; from simulated data for conductive heat transfer to real data for dynamic features of heat transfer
- CEN-ISO standards for heat transfer assessment

The cost for the six day-long Summer School is **500 Euro**. This covers:

- Handout of lecture notes and relevant papers.
- During lecture period Lunches and Coffee breaks.
- Social event and dinner during the weekend break.

Registration - The deadline for submission is 15th June 2022.

For registration and communication with the students, download and upload of documents, etc. the organisers are using the services of CIEMAT - PSA. See last page also.

Participants should do a pre-registration by sending a notification to Marta Ruiz; e-mail: mruiz.serviciosexternos@psa.es . For further information follow the DYNASTEE web-site; www.dynastee.info Upon pre-registration further information about accommodation and payment of the participation fee, will be sent.

ABOUT THE COURSE

Building Physics and Mathematical Models.

Lectures (>12) will provide the necessary background information on building physics to support the development of mathematical models for energy performance assessment. This includes knowledge of thermodynamic processes, in particular heat transfer and the impact of solar radiation. Topics like thermal conduction, convection and radiation will be presented as well as thermal mass. Using data-series for analysis the students will be introduced to the complexity of the physical process and how to translate the available information in mathematical models, e.g. the importance of model simplification of building physics represented by measured signals. In particular the variability of the environments and the uncertainty of data will be discussed, e.g. how to deal with measured data and not-measured phenomena and how to build a mathematical model based on the available input.

Models and model building

Linear transfer function models. Topics such as identification, formulation, estimation, and validation are presented. Furthermore, impulse response models, transfer function models, ARX, ARMAX and Box-Jenkins models and how to use these techniques to estimate values like the UA-value, gA-value and time constants of a building or a component will be covered.

Linear and non-linear state-space models. Topics such as identification, formulation, estimation, validation and Kalman Filter techniques are presented. In addition, lumped parameter models, RC-models, models, and combining information from data with prior information from physics are presented. Participants will learn how to use these techniques to estimate detailed physical quantities like the heat capacitance, window areas, solar aperture, effect of wind speed, nonlinear heat transfer, and non-stationary heat transfer.

Modelling building components and whole buildings.

In this part the potential of the tools presented within the course to model building systems will be demonstrated. The modelling of building components and whole buildings are presented as examples. All the complementary aspects of their analysis will be described in detail.

It will be emphasised that once sufficient skill in using tools are achieved, they must be combined with physical knowledge and understanding of the physical system, to pick all relevant influences and simplify them when necessary to find optimum models. The implementation of the different physical assumptions in different modelling approaches is presented step by step. The performance of each considered model is analysed and discussed.

How to obtain results using different models and methods.

The presented analysis and validation approaches will be illustrated step by step using simple and well documented case studies dealing with increased complexity. The tool LORD will be used as well as routines in the R-environment.

Different building envelopes will be characterised using different analysis approaches for hands-on examples through exercises. This will guide students through the application of different analysis approaches. These examples are designed to provide participants with the skills to apply the different techniques of modelling and validation. The considered case studies include a wide representation of the physical phenomena that are present in actual buildings. The aim is to put the focus on how to transfer the main features of the physical systems to different modelling frameworks, in order to build candidate models. The different approaches will be presented “bottom up”, starting from the simplest, and gradually increasing complexity highlighting and discussing the main features added by each level of the corresponding modelling approach. The following approaches will be considered: average and pseudo-dynamic methods, transfer function models (using the statistical software R) and continuous-time state space models (CTSM-R).

Metering data.
Towards the end of the course the analysis of metering data will be presented and studied with real data. Discussed will be how to split climate correlated energy consumption from end-user energy consumption. This aspect is an important step in analysing metering data and reporting an energy performance value for a building.

Obligatory homework
The lecturers would like to get insight into the competence of the students at the start of the Summer School week. Homework has been prepared for the participants in order to a get a minimum homogeneous starting level with the objective of optimising the usefulness of lectures. The homework will be sent by 18 July to participants that have registered and paid the registration fee.

Participants will be asked to solve as homework a proposed common wall-exercise and report step by step, the analysis and validation carried out as clearly as possible. These reports must be submitted to the organisers before the start of the Summer School. In addition some reading material will be made available at the web-site.

Software
*Note that the software used during the Summer School is the tool LORD as well as routines in **R**. The latter is a free software environment for statistical computing and graphics.*

*Find on the internet more information on **R** http://www.r-project.org/ and **RStudio** http://www.rstudio.com / (open source software).*

It would be wise to study the basics of the software when you want to get the best out of the Summer School week. Examples will be presented and discussed for LORD and R routines.

LORD is available on request and runs on Windows systems. To obtain a copy, please sent an e-mail to hans.bloem@inive.org

Preliminary programme.
The daily programme is organised around lectures and exercises each morning and afternoon session. The six-day-long programme offers >12 lectures and as much time for exercises as possible. The first day is focused on the homework exercise that should be presented by each participant, highlighting the solutions and problems in the approach of solving the heat transfer through a wall.

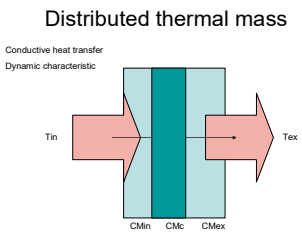
What can you expect from us?
The main purpose of this summer school is to train a methodology for evaluation of in-situ measured data and metering data. Information on relevant software (like CTSM-R) will be given and software tools (like LORD) will be used in the exercises using benchmark data.

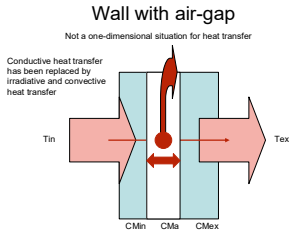
Six enthusiastic lecturers will teach methodologies in >12 60-minutes presentations for assessing the heat transfer characteristics of building envelopes as well as whole building using data for hands-on exercises (12 slots of 90 minutes).

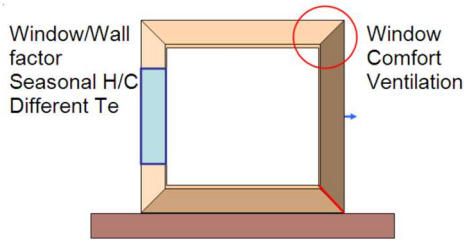
Several specific cases will be offered to participants, dealing with increased complexity, e.g. :

1- conduction only dealing with distributed thermal mass,
2- combined conduction, convection and radiation processes dealing with air gaps
3- closed environments like a building.

Exercises will deal with benchmark data that brings the fore mentioned complexity to the front. See the illustrations on the next page.







Conduction only | Conduction, convection and radiation | Volume/Surface environment

The participant will return home with data, software and acquired knowledge. You may get access to lots of more data, articles and documents that may enhance to build a skill on the application of a methodology for assessing thermal characteristics of whole buildings and building elements.

What we expect from you
1) Hand in the solution to a preparation exercise before the Summer School starts.
2) Follow the Summer School for all 6 days, 7th to 14th September 2022 in Almeria, Spain.

Note that you have to bring your own computer, preferably having installed the software environment R and R-Studio. LORD will be made available upon request.

Date: 7 - 14 September 2022 in Almeria, Spain

Venue: The Summer School will take place at **CIESOL, University of Almeria, Spain.**
Almeria can be reached in different ways. The most common travelling option is to fly to Madrid or Barcelona and then to Almería. It is also possible to fly to Malaga or Granada and then take a bus. Some direct flights to Almeria exist.
See https://www.turismodealmeria.org/en/travel-preparations/how-to-get-there/

You are advised to do your own hotel booking in due time. A list of available hotels is being prepared and will be sent upon pre-registration. The Summer School organization facilitates free transport by bus from a central point in Almeria to the CIESOL lecture hall.

You are advised to use the **registration forms** for the Summer School 2022. The form will be sent to you after pre-registration.

How to register to the Summer School 2022?

The deadline for submission is 15th June 2022.

Pre-registration for the Summer School on ***"Towards whole building analysis from in-situ measurements and metering data***" is simple. Participants should do a pre-registration by sending a notification to Marta Ruiz; e-mail: mruiz.serviciosexternos@psa.es

The cost for the 6 days Summer School is **500** Euro. Carry out the payment as instructed in the separate form that will be sent to you after pre-registration.

Note that the Summer School requires a minimum of 16 registered participants by 15h' of June 2022 and that it is limited, for practical reasons, to a maximum of 30 participants.

Additional information
For further information on the content of the course, please contact:
Hans Bloem hans.bloem@inive.org

For further information on practical issues potential participants can contact:
Maria Jose Jimenez mjose.jimenez@psa.es,

Social Event

Saturday 10 September.
An event is organised for all participants followed by a diner. **Details will follow.**

Previous courses organized by DYNASTEE
Have a look at the DYNASTEE web-site http://dynastee.info/ for an impression of the previous Summer Schools that started in 2012 in Denmark. The last physical took place in 2019 in Granada, Spain.
You may find further information in DYNASTEE Newsletters on the web-site.

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