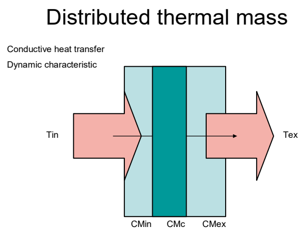
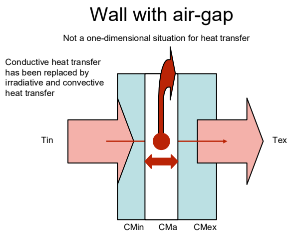
ABOUT THE COURSE

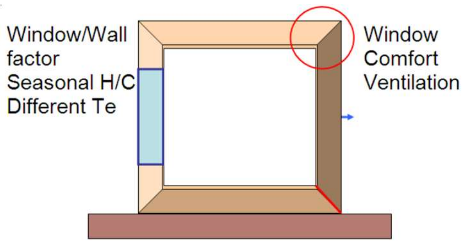
The Summer School 2019 will offer, for the first time, the possibility to have 2 levels (these will be described below) and to take the opportunity to certify working hours for the doctorate programme (> 60 hours of lectures and exercise time; see further).



Level 1 (9-13 September) will focus on energy flows through walls with distributed thermal mass (mainly by conduction). Initial assessment will be based on physical processes that are presented by mathematical models. Thermal characteristic parameters are the thermal resistance, capacitance and time constant. Impact of solar radiation, convection and variable climate conditions will be discussed. Analysis methods that will be used have an increased complexity.



Level 2 (16-20 September) will focus on the energy balance and deal with all physical processes, e.g. conduction, convection and radiation. Heat loss coefficient and solar aperture are to be identified. The applications are complex systems such as facades with air gap as well as whole buildings, closed environment, e.g. Volume/Surface



For both levels **benchmark data** will be used. 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.

What can you expect from us?
The main purpose of this summer school is to train a methodology for evaluation of measured data. You will be trained to apply a step-wise approach to understand the available data and to decide on an appropriate method and select a mathematical model. During each week, five enthusiastic lecturers will teach methodologies in >10 one-hour presentations for assessing the heat transfer characteristics of building envelopes as well as whole building using data for hands-on exercises (10 slots of 90 minutes). Information on relevant software (like CTSM-R) will be given and software tools (like LORD) will be used in the exercises. Read more in *Software techniques applied to thermal performance characteristics.pdf* on www.dynastee.info under the menu-item data analysis (overview) that contains other useful documents also.

The participant will return home with data, software and acquired knowledge. A USB stick contains 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 buildings and building elements.

What we expect from you!

To obtain a certificate of training doctoral activities from the International Doctorate School of the University of Granada (recognized as a part of the training part of the Doctorate programs) you have to fulfil some requirements:

1) Hand in the solution to a preparation exercise before the Summer School starts. This homework exercise aims to introduce the assessment of thermal characteristics.
2) Follow the Summer School for all 10 days, 9^{th} to 20^{th} September 2019 in Granada, Spain. One week course is 30 hours and completion of two weeks are 60 hours.
3) Complete the activities during the Summer School, under the teacher's guidance.

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.

FURTHER INFORMATION.

Building Physics and Mathematical Models.

The lectures (>10 per week) 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 CTSM-R and 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).

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 who 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 CTSM-R and 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 all software.
CTSM-R*, Continuous Time Stochastic Modelling for R is a free, open source and cross platform tool for identifying physical models using real time series data. Visit www.ctsm.info for all information and how to install CTSM-R on your computer.*
LORD *is available on request and runs on Windows systems. To obtain a copy, please sent an e-mail to* hans.bloem@inive.org

Additional information
For further information on the content and on practical issues potential participants can contact:

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GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

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DYNASTEE