# Pontifical Catholic University of Parana
# Mechanical Engineering Graduate Program

## 3rd PUCPR International PhD School on Energy

# Non-Deterministic Approaches for Assessment of Building Energy and Hygrothermal Performance

**Curitiba, Brazil**

## INTRODUCTION

The Mechanical engineering Graduate Program at the Pontifical Catholic University of Parana (PUCPR) is organizing a 3rd edition of the PhD international school in the PUCPR strategic area of Energy, which is an initiative to promote the scientific and technological growth of the area, including risk assessment of energy and hygrothermal performance of buildings.

This school is also in the frame of a French-Brazilian project (CAPES-COFECUB # 774/2013), which focus is on the state-of-the-art knowledge about heat, air and moisture response of building materials, and whole-building energy and hygrothermal simulation. Topics of the course includes the physics behind energy efficiency, uncertainty analysis, sensitivity analysis, stochastic processes, building energy simulation and moisture disorders in buildings.

Topics will be split into knowledge input and hands-on examples during the lessons.

Graduate students might be interested to know that this international school may be valid for 3 credits in the Brazilian graduate system.

A film with comments about the 1st edition can be found at www.pucpr.be/ppgem.

## LOCATION and IMPORTANT DATES

Location: Pontifical Catholic University of Parana - PUCPR, Curitiba, Brazil
Lessons Period: August 17th to August 24th 2014, totalizing 45 h.
Application Period: July 1st to July 31st 2015
Selection period: from July 8th 2015
Confirmation of acceptance: from July 12th 2015
Registration Period: from July 12th 2015 to August 6th 2015 (Limited to 20 students)

Aerial view of PUCPR Campus at Curitiba

## LECTURERS

Hélcio Orlande
Federal University of Rio de Janeiro

Jeanne Goffart
Pontifical Catholic University of Parana
Université de Savoie, France

Julien Berger
Pontifical Catholic University of Parana

Mickael Rabouille
Pontifical Catholic University of Parana
Université de Savoie, France

Marx Chhay
Université de Savoie, France

Nathan Mendes
Pontifical Catholic University of Paraná – PUCPR, Brazil

## APPLICATION AND REGISTRATION

The selection of students will be based on the CVs of applicants and their affinity to the theme of this school. Both CV and application form should be sent to the following email address: strictosensu@pucpr.br. Please be aware there is a limit of 20 students.

Updated information can be found at www.pucpr.br/ppgem

No enrollment fee will be applied (fully free).

## PHD INTERNATIONAL SCHOOL APPLICATION FORM

SURNAME ..... .
Name ..... .
Affiliation ..... .
Address ..... .
..... .
Email : . .....
Phone: ..... .
Provide a brief description (max. 10 lines) of your research project

Date……Signature…….

To be sent to strictosensu@pucpr.br

## Uncertainties Related to Building Energy and Hygrothermal Performance

## Modeling of Porous Building Elements

Nathan Mendes

Thermal Systems Laboratory, Mechanical Engineering Graduate Program, PUCPR

Energy and durability issues are some of the most important topics towards sustainability in the building sector and there is a large potential for energy savings. The results from the IEA-EBC project RAP-RETRO (IEA Annex 55) was intended to improve methods and tools for integrated evaluation and optimization of retrofitting measures. The results from the project are presented in a number of reports. Each of these reports are handling a specific task such as stochastic data description and collection, probabilistic methods, framework for risk assessment as well as reports from the practice and guidelines in the participating countries. This lecture will provide an introduction to building energy and hygrothermal simulation and a discussion about related uncertainties. In addition, the research work carried out in the frame of both IEA Annex 55 and CAPES-COFECUB # 774/13 project will be also presented.

## Bayesian Methods

Hécio Orlande

Federal University of Rio de Janeiro (UFRJ)

## Introduction to Stochastic Process

## An applied approach

Marx Chhay

LOCIE, University of Savoie, France

This course is devoted to introduce basic concepts occuring in stochastic processes. From a global strategy to represent non-deterministic phenomenæ, we will focus on the probabilistic

approach for modelling random processes step by step. Notions of Markov chains (transition matrix, joint probability mass function, ...), random processes of order n (mean and correlation func-tions, ...), and Markov processes (focus on random walk) will be performed. Following the time and the interest of the students, it will be possible to go further and introduce the tools related to stochastic diffusion processes. The course (' 8 h) will be illustrated with practical examples to be implemented by the students. Reminders on probability and statistic will be done when needed. Links with others courses will be also set.

## Introduction to Moisture Disorders in Buildings

Julien Berger

Thermal Systems Laboratory, Mechanical Engineering Graduate Program, PUCPR

Excessive levels of moisture in buildings lead to building pathologies. Moisture also has an impact on the indoor air quality and the hygrothermal comfort of the building's occupants. The course gives an introduction on the different types of damage and their mechanism caused by moisture in buildings. The global framework of the actual regulations to considers this risk in buildings construction will be introduced. Furthermore, this course proposes possible applications of the tools for sensitive analysis presented during the school.

## Introduction for easy use of descriptive analysis techniques and regression methods

Laura Michel

Thermal Systems Laboratory, Mechanical Engineering Graduate Program, PUCPR

Thermal Systems Laboratory, Department of Mechanical Engineering, PUCPR

Many statistical problems can be described using regression models: the aim corresponds therefore in exhibiting the relationships between different sets of variables (e.g. obtained from experimental protocol) without involving theoretical modelization. The purpose of the course is to introduce the standard tools associated to this approach. First at all, the techniques of descriptive analysis are presented. Indeed, descriptive analysis allows to provide the main statistical informations (correlations, indicators, ...) using a graphical representation of the whole set of data. Then, regression methods are exposed and discussed: their advantages and disadvantages, and keys to understand when they may be implemented or not.

All along the course, the relevant terminology and definitions in the framework of statistical analysis are set, just as basics of descriptive statistics and linear regressions. Worked cases will illustrate the concepts too. Duration is around 4 hours.

## Methods for uncertainty and sensitivity analysis : introduction and application

Jeanne Goffart and Mickaël Rabouille

Thermal Systems Laboratory, Pontifical Catholic University of Parana, Curitiba, Brazil

### Introduction

The sensitivity and uncertainty analysis becomes an essential tool to gain reliability in complex models such as those involved in building performance simulations. Such analysis may estimate an output confidence interval (uncertainty analysis) but also may identify the input(s) responsible for the uncertainty (sensitivity analysis). These statistical methods lead to a better understanding in complex models and the possibility of reducing the output uncertainties.

### Course objectives

The aim of the course is to introduce the student to the sensitivity and uncertainty analysis methods. The student will receive basic skills, an overview and some key information for the good use and practice of these stochastic tools. He or she will be able to use these methods in case of future research work.

### Course content

The uncertainty analysis will be treated in a first part. The focus will be on its definition, its propagation into a model and its representation. The sampling-based methods such as the classical Monte Carlo method or the most powerful Latin Hypercube Sampling (LHS) will also be presented and discussed.

In a second part, the sensitivity analysis methods will be introduced. Focus will be made on the global sensitivity analysis and especially on the variance-based methods such as the RBD-FAST method or the Sobol indices.

All of the topics covered in this course will be reinforced during a practical approach with Matlab. Some analytical function examples and more complex models from the building performance simulation will be used.

### Suggested Reading

We recommend the following reading:

Bertrand Iooss, Paul Lemaître. A review on global sensitivity analysis methods. C. Meloni and G. Dellino. Uncertainty management in Simulation-Optimization of Complex Systems: Algorithms and Applications, Springer, 2015, available in

https://hal.archives-ouvertes.fr/hal-00975701/document