# Advanced graduate course

**Inverse Modelling in Earth and Environmental Sciences**

**Lecturers:**

- Jasper Vrugt (University of California, Irvine)
- Sander Huisman (Forschungszentrum Jülich)

<table>
<thead>
<tr>
<th><strong>Time:</strong></th>
<th>July, 30 – August, 3 2012</th>
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<tbody>
<tr>
<td><strong>Location:</strong></td>
<td>KU Leuven, Campus Heverlee</td>
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**Organizers:**

- Jan Vanderborght (Agrosphere, Forschungszentrum Jülich)
- Jan Diels (Department of Earth and Environmental Sciences, KU Leuven)

**Email(s):** j.vanderborght@fz-juelich.de; jan.diels@ees.kuleuven.be

**Language:** English

**Objectives:**

The course objectives are to familiarize the participants with new algorithms that have been developed to estimate model parameters from experimental data using inverse modelling. Evenly important is the estimation of the uncertainty of the estimated parameters. In inverse modelling, parameters are estimated by minimizing an objective function that quantifies the difference between the model predictions and the observations or measurements. The models that are used in earth and environmental sciences generally predict non-linear and coupled processes. The non-linearity of the models makes that the objective function may be characterised by multiple local optima. Therefore, global optimisation algorithms that search the parameter space in an efficient way are required to find a global optimum. Often, measurements of different state variables, fluxes and indirect information about the model parameters are available. In order to reconcile these different information sources with model predictions, a multi-objective optimization procedure is required. Data are afflicted with uncertainty and contaminated by ‘errors’ and a process model is always a simplified representation of reality. This uncertainty and simplification are propagated in an uncertainty of the estimated model parameters and the model predictions.

In this course, algorithms for efficient sampling of the parameter space, treating multi-objective optimisation problems, and estimating parameter and model prediction uncertainty in the presence of model error will be presented and applied in practical exercises.
Prerequisites and target group:

The course targets researchers and students in earth and environmental sciences that want to interpret experimental data using process models. Prior to the course, a set of papers and reading material developing the theory behind the algorithms that will be covered in the course will be made available.

Contents:

- Introduction to inverse modelling
- Classical single objective optimization and linearized parameter uncertainty estimation
- Global search algorithms
- Multi-objective optimization
- Bayes Law: prior, likelihood, posterior
- Parameter uncertainty using Markov Chain Monte Carlo simulation
- Data assimilation using joint parameter and state estimation
- Working towards your own inverse modelling application

Teaching methods:

Reading material on the theory will be made available before the course starts. The morning sessions will be used to explain the theory and the working of the algorithms. In the afternoon sessions, the algorithms will be applied in exercises on PC. For the afternoon sessions, a working knowledge of MATLAB is required.

Evaluation methods:

- Is an active and quoted evaluation of the student who participates to the activity by the instructor possible (e.g. Is it possible to have an examination)?
  No

- Will the evaluation by the participants be organised (i.e. will the standard evaluation forms be used)?
  Yes
Other information:

You can apply for course participation by sending an informal e-mail to Sofie Bruneel (sofie.bruneel@ees.kuleuven.be) before June, 22. Please provide a brief summary of your research interests (~1 page) with your application. The number of attendees is limited to 30. If there are more than 30 applications, we will select candidates based on how well the research interests match the course content. You will be notified before June, 29 whether your application has been accepted.

After your application has been accepted, you should transfer the registration fee of 300 Euro (students, researchers at universities and non-profit research organisations) or 1000 Euro (others) to the following account:

Account number: 432-0000011-57
BIC: KREDBE BB
IBAN: BE09 4320 0000 1157

Account holder:
K.U.Leuven
Oude Markt 13
BE-3000 Leuven, Belgium

Please mention: ‘name + 400/0007/22081’

This fee includes the course documentation and a social dinner. Students of the Department of Earth and Environmental Sciences at the KU Leuven and students that are member of the ENVITAM graduate school can apply for a scholarship. Applications should be sent to Prof. Jan Diels (students of EES) (jan.diels@ees.kuleuven.be) or to Prof. Marnik Vanclooster (ENVITAM students) (Marnik.Vanclooster@uclouvain.be) with cc. to sofie.bruneel@ees.kuleuven.be.

Accommodation in student dorms (20-40 € per day and per person) is available. Students who wish to use this cheap but modest accommodation can contact Sofie Bruneel (sofie.bruneel@ees.kuleuven.be) before June, 29 or check the following web sites:

Cheap Hostels:
ratings of 20 € to 40 €
www.hostels.com/leuven-belgium?source=hostelscomnew&kid=00170813&aid=3&gclid=CMuHgPbwoq8CFchG3godjStEWw

All accommodation
http://www.booking.com/hotel/be/leuven-city-hostel.nl.html?aid=318615;label=Dutch_Whole_Site_Reset_inurl:.nl.html