**PE&RC - SENSE Postgraduate Course**

**The Art of Modelling – June 2017**

***Programme***

**Day 1: Introduction**

Introduction 1 (Katrien Descheemaeker, 12-6, 9.00-9:45):

* course introduction
* why modelling
* model types
* systems analysis
* model design scheme

Lecture 1 (Pytrik Reidsma, 12-6, 10.00-11.45):

Syllabus Chapter 1, 2

* state-rate approach
* relational diagrams
* building a model
* analytical integration
* numerical integration
* 3 simple examples
* introduction Visual Grind
* time coefficient
* time step
* feedbacks
* unit analysis

*Exercises L1 (Pytrik Reidsma, 12-6, 11.45-12.45 + 13.30-14.15):*

* *Chapter 2 (\* = additional)*

*Reflection 1 (12-6, 14.15-15.15)*

* *Reflection on own PhD research: what type of model do I want to make?*
* *What are the state variables?*
* *What are the rate variables?*
* *Sketch the change over time of the main state variable(s) and associated rate variable(s)*
* *What would be a reasonable time step for the model?*
* *Discuss with another course participant*

Lecture 2 (Pytrik Reidsma, 12-6, 15.30-17.15):

Syllabus Chapter 3

* building more complex model
* crop production
* equilibrium
* model quantification

**Day 2: Differential equations & time, crop production**

*Case study 1 (Pytrik Reidsma, 13-6, 9.00-12.45 & 13.30-15.15):*

* *Chapter 3, case study crop production*

Guest Lecture 1 (13-6, 15.30-17.15): Egbert van Nes

* visual grind
* stable states
* resilience

**Day 3: Differential equations & time, population ecology**

Lecture 3 (Pytrik Reidsma, 14-6, 9.00-10.45):

Syllabus Chapter 4

* exponential growth
* logistic growth
* logistic growth of interacting populations (with notes on paralogistic growth, development)

*Exercises L3 (Pytrik Reidsma, 14-6, 11.00-12.45):*

* *Chapter 4,4.1-4.10*

*Case study 2 (Pytrik Reidsma, 14-6, 13.30-16.30):*

* *Chapter 3, case study soil organic matter (ex. 3.7)*

*Reflection 2 (14-6, 16.30-17.15)*

* *Continue from day 1*
* *Draw a relational diagram of your model*
* *Write down the equations of your model*
* *What types of functions occur in your model?*

**Day 4: Differential equations & time, intro Matlab**

Lecture 4 (Pytrik Reidsma, 15-6, 9.00-10.45):

Syllabus Chapter 4, section 4.4; Chapter 6

* development
* numerical integration methods
* introduction Matlab
* reflection case studies crop production & soil organic matter

*Exercises L4 (Pytrik Reidsma, 15-6, 11.00-12.45):*

* *Chapter 4,4.11-4.14; Chapter 6, Tutorial Matlab, Chapter 5 selection*

*Case study 3 (Pytrik Reidsma, 15-6, 13.30-16.30):*

* *Chapter 3, case study soil organic matter & crop growth modelling (ex. 3.8)*

*Reflection 3 (15-6, 16.30-17.15)*

* *Continue from day 3*
* *Is a specific numerical integration method required for your model?*
* *Discuss your model with another course participant*

**Day 5: Model evaluation**

Lecture 5 (Katrien Descheemaeker, 16-6, 9.00-10.45)

Syllabus Chapter 7

* model performance:
	+ qualitative assessment
	+ more quantitative approaches: one-on-one line, maximum likelihood
	+ basic definitions: calibration, validation, inverse modelling
	+ relation between inverse modelling and model performance
	+ parameter certainty and uncertainty
	+ example on soil organic matter

*Exercises L5 (Katrien Descheemaeker, 16-6, 11.00-12.45):*

* *Chapter 7 (\* = additional). Focus on exercises 7.2, 7.6, 7.7, 7.8*

Lecture 6 (Katrien Descheemaeker, 16-6, 13.30-14.15):

Syllabus Chapter 7

* model performance
* inverse modelling

*Exercises L6 (Katrien Descheemaeker, 16-6, 14.30-15.15):*

* *Chapter 7, inverse modelling: exercises 7.4 and 7.5.*

Guest lecture 2 (16-6, 15.30-17.15): Bob Douma

* Parameter Estimation Techniques

**Day 6: Differential equations in time & 1D space**

Lecture 5 (Katrien Descheemaeker, 19-6, 9.00-10.45)

Syllabus Chapter 8

* space: partial differential equations
* space in 1D: heat flow example
	+ numerical solution of heat flow problem

*Exercises L5 (Katrien Descheemaeker, 19-6, 11.00-12.45):*

* *Chapter 8 (\* = additional)*

*Reflection 4 (19-6, 13.30-15.15)*

* *Continue from day 4*
* *Do your state variables vary in space?*
* *If yes, how & what would be an appropriate spatial unit?*
* *If no, further improve your relational diagram, the model equations & the quantification of your model*
* *Prepare pitch on why your modelling is interesting (of 3 slides), for Tuesday*

Guest lecture 3 (19-6, 15.30-17.15): Wolf Mooij

* Database approach

**Day 7: Differential equations in time & 1D space**

Lecture 6 (Katrien Descheemaeker, 20-6, 9.00-10.45)

Syllabus Chapter 9

* space: partial differential equations
* general transport equation
	+ mass flow and diffusion
	+ numerical solution
	+ choice of Δz

*Exercises L6 (Katrien Descheemaeker, 20-6, 11.00-12.45):*

* *Chapter 9 (\* = additional)*

*Reflection 5 (20-6, 13.30-15.15)*

* *Pitches (half an hour)*
* *Start working in groups of 3 on 1 model*

Guest lecture 4 (20-6, 15.30-17.15): Arend Ligtenberg

* Agent based modelling and spatial modelling

**Day 8: 2D space**

Lecture 7 (Katrien Descheemaeker, 21-6, 9.00-10.45):

Syllabus Chapter 10

* Partial differential equations in 2D: an example of vegetation patterning in arid environments
* Development and application of 2D model

*Exercises L7 (Katrien Descheemaeker, 21-6, 11.00-12.45):*

* *Chapter 10*

*Reflection 6 (21-6, 13.30-17.15)*

* *Continue working in groups of 3 on 1 model*
* *Discuss models of others in the group*
* *Include a sensitivity analysis, calibration and validation scheme*

**Day 9: Case study on Nutrient flows**

*Case study 4 (Katrien Descheemaeker, 22-6, 9.00-12.45 & 13.30-15.15)*

* *Chapter 11, case study nutrients*

Case study 4, plenary discussion (22-6, 15:30 – 17:15)

**Day 10: Presentations**

*Reflection 8 (23-6, 9.00-12.45)*

* *exercise with your model*
* *report on your model results*
* *prepare presentation ( 3 powerpoint slides)*
* *extra: make additional exercises from Chapter 5 / 13*