Venice International University
VIU Graduate Seminar
Hydrogeophysical inversion and data assimilation for the characterization and monitoring of coastal aquifers.

July 1 – 5, 2019

Faculty

Erwan Gloaguen, INRS, Canada (Coordinator)

Bernard Giroux, INRS, Canada

James Irving, University of Lausanne, Switzerland

Niklas Linde, University of Lausanne, Switzerland

Matteo Camporese, University of Padua, Italy

John Molson, Laval University, Canada

Philippe Renard, University of Neuchâtel, Switzerland

Day 1, Monday July 1

9:30 - 09:45 – Introduction to the course: aim and structure (E. Gloaguen, INRS)

9:45 - 10:00 – A one-minute Students' introduction

10:00 - 10:30 – The challenge of groundwater management in coastal aquifers (E. Gloaguen, INRS, Matteo Camporese, University of Padua)

Rising pressure on coastal areas due to population growth and presence in coastal regions, seawater intrusion, climate change, irrigation and food production, a few examples

10:30 -10:45 – Discussion time

10:45 - 11:30 – Back to basics (J. Molson, Laval University)

Review of the physics of groundwater flow, role of density in heads, how to represent seawater intrusion: the different approaches: sharp interface, some examples of simple analytical solutions (Ghyben-Herzberg), advection-dispersion equations and mixing with density dependence

11:30 - 11:45 – Break

11:45 - 12:30 – Hydrogeological modelling (J. Molson, Laval University)

How to solve numerically those equations, boundary & initial conditions, what are the different techniques, advantages and disadvantages, accuracy criteria & numerical error, what are the codes and tools available, key issues?

12:30 - 12:45 – Discussion

12.45- 13:45 – Lunch

13:45- 15:30 – Important knowledge about these systems gained by numerical modeling (J. Molson, Laval University)

The Henry problem and its variants, demonstration, effect of 3D geometry of the aquifer base, effect of the heterogeneity of the aquifer in 2D, or in 3D. A real case example. Necessity to characterize geometry and parameters in the field.

15:30- 15:45 – Discussion time

15:45 - 16:30 – Uncertainty and geostat (P. Renard, University of Neuchâtel)

Basic concepts of geostatistics to represent uncertainty and model spatial and temporal heterogeneity, variogram, kriging, simulation / demo with free software ar2gems

16:30 - 16:45 Break

16:45 - 17:30 Students' Poster Session

Day 2, Tuesday July 2

09:30 - 10:15 – First day follow up (J. Molson, Laval University)

Correction of the exercise given by John Molson at the end of his class the first day. Summary / clarification of previous day / discussion with participants

10:15 - 11:00 – Geostat follow-up (P. Renard, University of Neuchâtel)

Follow up on geostat and illustration on 2 examples: the Cape Bon example in Tunisia / geostat on geology / and source term : pumping rate are not well known consequences for seawater intrusion / Oman: geostat + inverse on tidal data + optimization of pumping scheme

11:00 - 11:15 – Break

11:15- 12:00 – The limits of the multigaussian model (P. Renard, University of Neuchâtel)

Concept of connectivity, impact on flow and transport, overview of alternative geostatistical models: objects, plurigaussian and MPS

12:00 - 12:15 – Discussion

12:15 - 13:30 – Lunch

13:30 - 14:15 – Introduction to hydrogeophysics (N. Linde, University of Lausanne)

The promise, petrophysics, quick tour of illustrative examples, outline of the next 1.5 days

14:15 - 14:30 – Discussion

14:30 - 15:15 – Geophysical methods (electrical resistivity tomography, time-domain and frequency-domain electromagnetics, seismic reflection and refraction) (B. Giroux, INRS)

Basic underlying physics, experimental setup (including monitoring), modelling

15:15 - 15:30 – Break

15:30 - 16:15 – Geophysical methods: continuation of lecture (B. Giroux, INRS)

16:15 - 16:30 – Discussion

16:30 - 17:15 – Students' Poster Session

Day 3, Wednesday July 3

09:30 - 10:15 – Geophysical methods – part II (B. Giroux, INRS)

Continuation of lecture or computer exercise

10:15 - 10:30 – Discussion

10:30 - 11:15 – Deterministic inversion theory (including time-lapse) (J. Irving, University of Lausanne)

11:15 - 11:30 – Break

11:30- 12:15 – Deterministic inversion theory (including time-lapse): Continuation (J. Irving, University of Lausanne)

12:15 - 12:30 – Discussion

12:30 - 13:30 – Lunch

13:30 - 14:15 – Advanced inversion topics (N. Linde, University of Lausanne)

Coupled hydrogeophysical inversion, joint inversion and multimethod surveys, outstanding challenges (e.g., non-uniqueness and resolution limitations)

14:15 - 14:30 – Discussion

14:30 - 15:15 – Geophysics to study salt water intrusion problems (N. Linde, University of Lausanne)

Mapping current state vs. monitoring; local to regional scale; use of mobile acquisition platforms (boat, helicopter, airplanes), case-studies

15:15 - 15:30 – Break

15:30 - 16:15 – Geophysical case-studies related to salt water intrusion (J. Irving, University of Lausanne)

16:15 - 16:30 – Discussion

16:30 - 17:15 – Students' Poster Session

Day 4, Thursday July 4

09:30 - 10:15 – Introduction to data assimilation (M. Camporese, University of Padova)

Theory and assumptions of the Kalman filter. Extension to nonlinear models: the ensemble Kalman filter (EnKF) and its variants.)

10:15 - 10:30 – Discussion

10:30 - 11:15 – Relaxing the Gaussian assumption (M. Camporese, University of Padova)

The particle filter (PF) and possible implementations)

11:15 - 11:30 – Break

11:30- 12:15 – Application examples and demos of EnKF and PF in hydrogeological problem (M. Camporese, University of Padova)

12:15 - 12:30 – Discussion

12:30 - 13:30 – Lunch

13:30 - 14:15 – Introduction to machine learning (E. Gloaguen, INRS)

14:15 - 14:30 – Discussion

14:30 - 15:15 – Example of machine learning in geosciences and hydrogeological problems (E. Gloaguen, INRS)

15:15 - 15:30 – Break

15:30 - 16:15 – Wrap up

16:15 - 17:15 – Students' Poster Session

Day 5, Friday July 5

09:00 – 17:00 – Field trip to the Adige-Euganeo Reclamation Authority district (south of the Venice Lagoon)

Visit to the Ca' Bianca pumping station with a presentation of land management problems in coastal areas: subsidence, seawater intrusion, soil salinization. Excursion to parts of the district with evidence of those issues and adopted countermeasures