COURSE DETAIL

EARTH SYSTEMS MODELLING
Country Netherlands
Host Institution Utrecht University
Program(s) Utrecht University
UCEAP Course Level Upper Division
UCEAP Subject Area(s) Mathematics Environmental Studies Computer Science
UCEAP Course Number 146
UCEAP Course Suffix
UCEAP Official Title EARTH SYSTEMS MODELLING
UCEAP Transcript Title EARTH SYSTM MODELNG
UCEAP Quarter Units 6.00
UCEAP Semester Units 4.00

Course Description

This course is structured into four hands-on modules. Three modules are dedicated to using and developing different types of models typically used by Earth Scientists. Many models rely on solving Partial Differential Equations (PDE). They either represent an efficient simplification thereof, e.g., in the form of box modelling (module 2 or directly write and solve (un)coupled sets of PDE’s (module 3). A new branch of modelling constitutes data-driven modelling, which exploits artificial intelligence to build models based on observations (module 2). These first three modules integrate the learning of more advanced programming with acquiring the basics of different methods used for modelling. The last module focuses on the process of modelling itself, such that you can translate Earth Science problems into effective modelling strategies. Together these modules complete the programming, modelling and data skill learning lines. Participants develop and write their own box model with a complete numerical model, which quantifies to what depth the water level would fall if the Mediterranean Sea was disconnected from the Atlantic Ocean. The course teaches the development and uses data-driven models. Learn the basics of different machine learning models, including how neural networks, random forests, and long short-term memory algorithms work. Train models using hydrological data and optimize their performance on different data sets. Finally, you build a machine learning model from scratch to simulate a new hydrological data set. Participants also develop or program various codes from scratch, starting from physical conservation laws to writing codes to simulate 1D and 2D flow; heat, chemical and pressure diffusion; and coupled momentum and continuity equations with variable viscosity. Developments are based on a staggered grid, finite difference formulation, which facilitates understanding of numerical mathematics for Earth Science students. Through gradually increasing code complexity students are introduced to spatial and temporal discretization, initial and boundary conditions, and basic numerical solvers. Finally, learnings is applied to perform a numerical modelling research project. The thermomechanical code used for this module is an extension of the building blocks you have programmed yourself in the PDE-module. You can choose to apply this code to simulate subduction over millions of years to understand earthquake

sizes, flow of a mountain glacier, or tsunami propagation over a lake. Students are tasked to formulate a research question in one of these Earth Science domains based on literature and develop and execute a modelling strategy to answer it. Execute your research project step-by-step accumulating into a poster presentation. Assumed previous knowledge includes GEO1-1135, GEO2-1230 and GEO2-1301.

Language(s) of Instruction
English

Host Institution Course Number
Geo3-1355

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EARTH SYSTEMS MODELLING

Host Institution Course Details
https://osiris-student.uu.nl/onderwijscatalogus/extern/cursus

Host Institution Campus
Utrecht University

Host Institution Faculty
Faculty of Geosciences

Host Institution Degree

Host Institution Department

Course Last Reviewed
2025-2026

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