Hydrology MSc

Vrije Universiteit Amsterdam - Fac. der Aard- en Levenswetenschappen - M Hydrology - 2016-2017

The Hydrology master's programme provides the student with sound scientific knowledge of how water cycles through the Earth’s atmosphere, surface and groundwater systems and how water quantity and quality are modified due to natural processes, or in response to human interference with the water cycle (e.g. pollution, land use change, etc.). This knowledge is a prerequisite for the sustainable use of our water resources that are being threatened by the continuous increase in the world’s population and the associated increase in water use and agricultural and industrial pollution. As water issues are often not restricted to a single country, the Master’s programme is strongly oriented to provide an international perspective.

The programme is strong in both hydrogeology and ecohydrology. Hydrogeology deals with (un)saturated groundwater and surface water flows on a local to regional scale (0-500 km), groundwater exploration and water quality issues in relation to the geology and land-use. Groundwater and surface water flow patterns and associated variations in the chemical composition of water due to interaction with the environment are assessed using a combination of lectures, field studies and hydrological and hydrochemical modelling workshops. Exploration and water resources assessments are made through application of water balance techniques, geophysical techniques and chemical and isotope tracer methods. Ecohydrology focuses on processes regulating the hydrological cycle and how these are affected by changes occurring at the land surface in response to human activities (e.g. deforestation, climate change). It combines micro-meteorology, (forest) hydrology, Quaternary geology, and environmental sciences to study processes that regulate how water, nutrients, sediment and gases are exchanged between the soil, water, vegetation and the atmosphere. These transfers are studied mostly on small catchment scales. A range of field measurement and sampling techniques are used including micro-meteorology, hydrology, plant physiology, soil physics, chemical isotope tracer methods, in combination with detailed, process-based models.

The year schedule can be found at the FALW-website.
Further information about the MSc programme Hydrology.
A complete programme description can be found at the FALW-website.

Inhoudsopgave

Expired programme components Hydrology

The course programme components presented in the list below will no longer be part of the examination programme in academic year 2014-2014.

Vakken:

Naam	Periode	Credits	Code
Unsaturated Zone and Near Surface Hydrological Processes		6.0	AM_450021

MSc Hydrology year 1

Vakken:

Naam	Periode	Credits	Code
Catchment Response Analysis	Periode 1	6.0	AM_450003
Climate Hydrological Processes	Periode 4	6.0	AM_1196
Ecohydrology	Periode 1	6.0	AM_450014
Field Course Hydrology	Periode 5+6	12.0	AM_1169
Groundwater Processes	Periode 2	6.0	AM_1164
Integrated Modeling in Hydrology	Periode 3	6.0	AM_1165
Measuring Techniques in Hydrology	Periode 5	6.0	AM_1168
Water Economics	Periode 4	6.0	AM_1167
Water Quality	Periode 2	6.0	AM_1166

MSc Hydrology, year 2

Opleidingsdelen:

- MSc Hydrology year 2 elective options
- MSc Hydrology year 2 compulsory modules

MSc Hydrology year 2 elective options

Vakken:

Naam	Periode	Credits	Code

Advanced Groundwater Processes	Periode 4	6.0	AM_1171
Biological Oceanography	Periode 2	6.0	AMU_0021
Climate and Policy	Periode 3	6.0	AM_450188
Climate Hydrological Processes	Periode 4	6.0	AM_1196
Climate Modelling	Periode 3	6.0	AM_450004
Ecotoxicology and Water Quality	Periode 2	6.0	AM_1054
From Source to Sink: Chemical and Physical Cycles	Periode 2	6.0	AM_450146
Geothermal Energy	Periode 5	6.0	AM_450409
Global Biogeochemical Cycles	Periode 4	6.0	AM_450332
Groundwater Microbiology and Geochemistry (Geomicrobiology)	Ac. Jaar (september)	6.0	AM_450132
Modern Climate and Geo-ecosystems	Periode 1	6.0	AM_1124
Reflection Seismic for Geologists	Periode 4	6.0	AM_450170
Scientific Writing in English	Periode 2, Periode 5	3.0	AM_471023
Water Management	Periode 1	6.0	AM_468023

MSc Hydrology year 2 compulsory modules

Vakken:

Naam	Periode	Credits	Code
Master Thesis Hydrology	Ac. Jaar (september)	36.0	AM_1170

Advanced Groundwater Processes

Vakcode	AM_1171 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. ir. Y. van der Velde
Examinator	dr. ir. Y. van der Velde
Docent(en)	dr. ir. Y. van der Velde
Lesmethode(n)	Werkcollege
Niveau	400

Doel vak

The goal of this course is to deepen the understanding of groundwater processes for which the Groundwater Processes course laid the fundamentals. The objective is to make the student thoroughly familiar with the modelling of groundwater flow processes and the transport of solutes and heat through groundwater systems.

Inhoud vak
Hydrogeology is to a large extent concerned with the flow of water in the subsurface. Groundwater flow models are powerful tools to study this movement of water in the subsurface. Hence, they are widely used in research and consultancy, and thus a key skill for hydrologists. This course you will deepen your understanding of groundwater flow modelling and develop basic programming skills to investigate these processes. Moreover, fundamental transport processes taking place in groundwater bodies will be included in this (advection, diffusion, dispersion, first-order reactions) using numerical methods.

Onderwijsvorm
The course consists of a set of lectures supplemented with practicals.

Toetsvorm
Written examination

Doelgroep
Hydrology MSc students and other earth sciences related MSc programs

Biological Oceanography

Vakcode	AMU_0021 ()
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. G.M. Ganssen
Examinator	dr. G.M. Ganssen
Niveau	500

Inhoud vak
http://studiegids.uva.nl/xmlpages/page/2016-2017-en/search-course/course/1545258

Overige informatie
This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904, servicedesk-esc-science@uva.nl, +31 (0)20 525 7100.
Enrolment via https://m.sis.uva.nl/vakaanmelden is required.

Catchment Response Analysis

Vakcode	AM_450003 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen

Coördinator	dr. ir. M.C. Westhoff
Examinator	dr. ir. M.C. Westhoff
Docent(en)	dr. ir. M.C. Westhoff
Lesmethode(n)	Werkcollege, Computerpracticum
Niveau	400

Doel vak
The objectives of the course are to provide the student with scientific theory, tools and methods for understanding and evaluating the response of a catchment to precipitation in terms of surface water flows. This requires knowledge about processes regulating the flow of water on the land surface and in river channels, the techniques for quantification of surface water flows and statistical methods for predicting extreme runoff events. In addition, experience with surface water flow modelling for predicting the behaviour of rivers under different land use or climate conditions should be acquired.

The course contributes to the Knowledge and Understanding and Application of Knowledge and Understanding final attainment levels of the Msc Hydrology Programme. Knowledge and understanding is obtained through the studying of theory as provided in the reader, during the oral lectures and through self-study of scientific papers on rainfall-runoff response topics. Knowledge and understanding is applied in the setting up and execution of a rainfall-runoff model and the critical evaluation of the model simulation with measured data.

Inhoud vak
The course consists of three main topics. We start with an overview of hydrodynamic and hydraulic theory that governs flow in open channels. This is followed by lectures on discharge measurement techniques, catchment response analysis and runoff statistics. Topics are hill slope hydrology, hydrograph analysis, reservoir and flow routing and statistical methods to describe and quantify spatial and temporal variation in catchment runoff. The spectrum of available models for runoff modelling, from classical lumped models to data-demanding distributed, physically-based hydrological models, will also be discussed. Finally, theory and understanding will be applied in a series of modelling exercises applying the HBV-light rainfall – runoff model to simulate runoff of the Dinkel River in East Netherlands.

Onderwijsvorm
The tuition consists of ten classroom lectures and four computer modelling workshop sessions. The number of contact hours is in the order of 42.

Toetsvorm
The assessment is through a written exam (100%) and assessment of the modelling workshop report (which has to be passed before the written exam).

Literatuur
Bishop et al. 2008. Aqua Incognita: the unknown headwaters, Hydrological Processes 22: 1239–1242. doi: 10.1002/hyp.7049.

A,.A. van der Griend and M.J. Waterloo (2013), Catchment Response Analysis. Course Reader, VU University, Amsterdam.

B.L. McGlynn, J.J. McDonnel and D.D. Brammer. A review of the evolving perceptual model of hillslope Flowpaths at the Maimai catchments, New Zealand. Journal of Hydrology 257 (2002) 1-26.

J. Seibert, 2002. HBV light version 2 User's Manual. Environmental Assessment SLU, Sweden.

Seibert, J. and M.J.P. Vis 2012. Teaching hydrological modeling with a user-friendly catchment-runoff-model software package, Hydrology and Earth System Sciences 16: 3315-3325, doi:10.5194/hess-16-3315-2012, 2012.

I. Tromp-van Meerveld and M. Weiler. Hillslope dynamics modeled with increasing complexity. Journal of Hydrology (2008) 361, 24-40.

Links to other papers are provided on Blackboard.

Vereiste voorkennis
The student should be familiar with the subjects of the BSc course Introduction to Hydrology and Climatology (AB_1074) as detailed in the Introduction to Hydrology and Climatology (2013) course reader by M.J. Waterloo, V.E.A. Post and K. Horner.

Aanbevolen voorkennis
The student should have a good background knowledge of mathematics and physics at BSc level and have basic computer skills. In addition, the student should have basic knowledge of Earth Science, as provided by the System Earth course (AB_450067).

Doelgroep
First-year M.Sc. Hydrology students, students from Earth Sciences, Earth and Economy or Natural Sciences M.Sc. programmes.

Overige informatie
The course is open for participation to students from alternative M.Sc. programmes at the VU University Amsterdam, or from other universities. If you are a professional and wish to attend this course you can also participate on a contract basis. In both cases please do contact the course coordinator to find out if you fulfill the background knowledge requirements and for enrollment procedures.

Climate and Policy

Vakcode	AM_450188 ()
Periode	Periode 3
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. P.H. Pattberg
Examinator	prof. dr. P.H. Pattberg
Docent(en)	prof. dr. P.H. Pattberg
Lesmethode(n)	Werkcollege
Niveau	400

Doel vak
After studying this course, students should be able to define and explain key concepts of relevance to the climate change governance issue; understand the causes, impacts and effects of climate change and the key scientific controversies in the regime; be able to identify, explain and analyze the various policy options for mitigation and adaptation at different levels of governance; be able to understand and analyze the key political challenges in the climate change regime, the common problems facing all countries, the coalitions in the regime, the North-South, North-North, South-South, European and domestic political issues; be able to explain and assess the long-term objective, the principles, the commitments of countries and other key elements of the Climate Change Convention, the quantified commitments of developed countries, and the flexibility mechanisms under the Kyoto Protocol; be able to explain, analyze and form a judgment on the role of forestry in the climate change regime, and the various aspects of policy with respect to deforestation and land degradation; be able to define and explain the role of market mechanisms in the climate change regime, their advantages and disadvantages, and their potential in addressing the climate change problem; be able to integrate the information learnt thus far to assess and identify possible long term solutions to the climate change problem and the research questions that emerge from a study of the climate change regime; and be able to make a judgment about which principles, policy instruments and approaches are likely to be most efficient, equitable and/or effective in addressing the climate change problem.

Inhoud vak
International policy on human-induced climate change and its mitigation is a hotly debated subject. Current (international) climate policy is the result of a complex and long-lasting negotiation process at multiple levels of governance. In this process, the science of the complex earth and climate system is closely linked to questions on the socio-economic effects of climate change, the options for global environmental governance as determined by the structure of international organizations, international economic and political relations and environmental law. These close relations between earth system research and economic/political questions make this course an interesting subject for students with a bachelor’s degree in different subjects . The course includes:
- an overview of the science of climate change, its impacts (IPCC Fifth Assessment Report) uncertainties, mitigation, adaptation; - climate change policy options at multiple levels of governance; - analysis of the political challenges in climate change and the positions of different countries and actors; - assessment of the international legal instruments including the Climate Change Convention and the Kyoto Protocol, - assessment of the economics of climate change including analysing the flexible mechanisms (Emission trading, Clean Development Mechanisms, Reducing Emissions from Deforestation and Forest Degradation) and options for Post Kyoto measures; and paper discussions on a topical area of climate governance.

Onderwijsvorm
The course consists of 7-8 interactive lectures including class presentations and uses modern didactic approaches, films, and role play to help the students internalize many of the concepts and theoretical approaches developed.

Toetsvorm
The students will be examined on the basis of a paper (50%) and a closed book written examination (50%). Students must get a grade of 5.5 in each to pass in the examination.

Literatuur
Reader

Aanbevolen voorkennis
Basic knowledge of social science concepts such as governance

Doelgroep
Students with an interest in governance and policy

Climate Hydrological Processes

Vakcode	AM_1196 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. H. de Moel
Examinator	dr. D. Coumou
Lesmethode(n)	Werkcollege, Computerpracticum
Niveau	400

Climate Modelling

Vakcode	AM_450004 ()
Periode	Periode 3
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. D.M.V.A.P. Roche
Examinator	dr. D.M.V.A.P. Roche
Docent(en)	prof. dr. A.J. Dolman, dr. D.M.V.A.P. Roche
Lesmethode(n)	Werkcollege, Computerpracticum
Niveau	400

Doel vak
The objective of this course is to provide an overview of numerical climate models and their applications, with a focus on Earth Science studies.

Inhoud vak
Geological archives show convincingly that the climate system experiences variability on a wide range of time-scales. For Quaternary studies, climate variations at the following time-scales are most important: glacials-interglacials, millennia and centuries-decades. This course focuses at the mechanisms behind these variations, thereby using

climate models as a tool, i.e. numerical computer models in which the dynamics of the climate system are calculated. The combination of these models and geological data will be treated extensively. The course consists of lectures giving an overview of climate models and their application (different types for different time-scales), computer practicals and discussion meetings, in which students discuss the recent literature in detail. In this way the course considers case studies for the different time-scales and deals with recent developments in climate modelling. The following two questions are central to the course: 1) What is the driving mechanism behind climate change at a particular time-scale? 2)
How can we optimise the combination of climate models and geological data in order to increase our understanding of climate evolution?

Onderwijsvorm
Lectures, discussion meetings and computer exercises.

Toetsvorm
Compulsory participation in discussion meetings, computer exercises, oral presentation and written exam.

Literatuur
Text book:
Goosse, H. (2015) Climate System Dynamics and Modelling. Cambridge University Press, 358 p., ISBN 978-1-107-44583-3

Additional:
Lecture notes and selected papers (made available through Blackboard).

Overige informatie
The course is open for participation to students from alternative M.Sc. programmes at the VU University Amsterdam, or from other universities. If you are a professional and wish to attend this course you can also participate on a contract basis. In both cases please do contact the course coordinator to find out if you fulfill the background knowledge requirements and for enrollment procedures.

Ecohydrology

Vakcode	AM_450014 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. A.J. Dolman
Examinator	prof. dr. A.J. Dolman
Lesmethode(n)	Werkcollege, Computerpracticum
Niveau	400

Doel vak
Ecohydrology is a combination of ecology (study of how organisms interact with each other and with the natural environment) and hydrology (study of how water cycles in terrestrial environments). It focuses on the role of ecosystems in the water cycle of terrestrial landscapes. The objectives of the course is to provide understanding of the functioning

of ecosystems in relation to water availability and the movement of water in terrestrial ecosystems under different climates. This ecohydrological knowledge forms the basis for supporting decisions on sustainable land use from a water resources point of view. It requires fundamental theoretical knowledge on plant physiology and on the exchange of water between the soil, vegetation and the atmosphere. As such, limitations to ecosystem functioning posed by water availability in relation to evaporation and transpiration by different plant communities is a central theme in this course. In addition, the student needs to learn basic computer programming for meteorological data processing and analysis.

Inhoud vak
This course describes and discusses basic interactions between the vegetated land surface, the atmosphere and the hydrosphere. Basic questions dealt with include: what determines the broad vegetation patterns of the world, and how do these in turn determine the ecohydrological behaviour of different vegetation types? This requires understanding of primary ecohydrological processes (rainfall and cloud water interception, transpiration, soil moisture dynamics) and feedback mechanisms between the vegetation and the atmosphere as well as insight into the measurement, data analysis and modelling of these processes. The ecohydrological aspects of Dynamic Vegetation Models (DGVMs) will be discussed. Tropical and temperate deforestation impacts on catchment hydrological functioning and climate as well as desertification processes are considered. Ecohydrological processes in boreal and tundra regions, as well as in montane cloud forests will be discussed in some detail. Emphasis throughout the course is on a combination of process understanding, interpretation of experimental results, and modelling. Finally, a computer programming workshop is included to become familiar with the basics of computer programming, meteorological data processing, analysis and rainfall interception modelling.

Onderwijsvorm
The tuition consists of nine classroom lectures, a half-day student presentation session and a computer workshop (two half-days).

Toetsvorm
Written test on lecture notes and selected literature (65%), attendance of workshops (15%), and a presentation to be given on a pre-determined topic (20%).

Literatuur
Scientific papers and handouts are provided during the course via Blackboard

Vereiste voorkennis
The student should be familiar with the subjects of the BSc course Introduction to Hydrology (450024) as detailed in the Introduction to Hydrology (2012) course reader by M.J. Waterloo, V.E.A. Post and K. Horner.

Aanbevolen voorkennis
The student should have a good background knowledge of mathematics and physics at BSc level and basic computer skills

Doelgroep
First-year MSc Hydrology students, students from alternative Earth Sciences, Earth and Economy or Natural Sciences MSc programmes

Overige informatie
The course is open for participation to students from alternative M.Sc. programmes at the VU University Amsterdam, or from other universities. If you are a professional and wish to attend this course you can also participate on a contract basis. In both cases please do contact the course coordinator to find out if you fulfill the background knowledge requirements and for enrollment procedures.

Ecotoxicology and Water Quality

Vakcode	AM_1054 ()
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. ir. T.H.M. Hamers
Examinator	dr. ir. T.H.M. Hamers
Docent(en)	dr. ir. T.H.M. Hamers
Lesmethode(n)	Hoorcollege, Practicum
Niveau	400

Doel vak
At the end of this course, students will have:
1. Gained theoretical knowledge of contaminants in the environment, their effects on organisms and ecosystems, and the assessment of water quality
2. Learned to determine the ecotoxicological effects of chemicals with laboratory toxicity testing
3. Developed a critical academic attitude in environmental management issues by combining scientific information and socio-economic arguments

Inhoud vak
This course focuses on the effects of contamination of aquatic ecosystems, from the molecular chemistry of major groups of toxicants to their impacts at the molecular, cellular, individual, population, and ecosystem level.

The first part of the course is a laboratory practical, in which students gain hands-on experience in ecotoxicity testing using methods from bacteria, aquatic invertebrates and fish. Both whole-organism and molecular biological techniques are taught. Students will evaluate scientific literature and the results of their experimental research to assess the risk of environmental contaminants for ecosystem health. At the end of the practical, students will present the results of their experimental work in a poster presentation.

The second part of the course is theoretical and will teach the student the state of the art in ecotoxicology. It is designed as a scientific symposium with invited lectures by internationally renowned guest lecturers as well as PhD candidates who present their PhD research in ecotoxicology. Students take the role of chairperson during the symposium and introduce the speakers, ask questions and discuss critical issues. Topics include emerging compounds, molecular mechanisms

of toxicity, community effects, global environmental problems, and chemical regulation. Scientific literature will be given as background information on each topic. The symposium is finalized with oral presentations in which students present a critical evaluation of the topics presented.

Onderwijsvorm
• Laboratory practical course: 60 hours
• Lectures (introduction to practicals + scientific symposium): 24 hours
• Independent study

Toetsvorm
1. Participation in laboratory practical course, including lab journal (15%)
2. Poster presentation of the laboratory practical course (35%).
3. Oral presentation of scientific symposium (15%)
4. Written exam of 10 open questions (35% of mark)

The student has passed if each of the components has received a minimum of 5.0, and the final mark is equal to or higher than 5.5, in a range from 1-10.

Literatuur
Protocols for the laboratory practical will be provided.
For the theoretical part of the course, scientific articles will be provided by guest lecturers.

Vereiste voorkennis
BSc in Biology, Ecology, Biomedical Sciences, Health Sciences, Earth Sciences, Chemistry or related fields

Aanbevolen voorkennis
BSc course in Environmental Toxicology (e.g. AB_1020) is recommended but not mandatory.

Doelgroep
Open to all MSc students in Biology, Ecology, Biomedical Sciences, Health Sciences, Earth Sciences, Chemistry or related fields. Compulsory course for MSc Ecology, ECT specialization. Optional course for UvA MSc Biology, L&O track.

Overige informatie
For more information, please contact: Dr. Timo Hamers, Room A-667, 020-598 9529, timo.hamers@vu.nl

Lecturers:
Dr. Timo Hamers
Dr. Jessica Legradi
Dr. Michiel Kraak (UvA)

Field Course Hydrology

Vakcode	AM_1169 ()
Periode	Periode 5+6
Credits	12.0
Voertaal	Engels

Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. ir. M.C. Westhoff
Examinator	dr. ir. M.C. Westhoff
Lesmethode(n)	Werkcollege, Computerpracticum, Veldwerk
Niveau	500

Doel vak
This course main objective is to instill “hydrological system thinking” in the student's mind. This is done through a combination and practical application of the earth scientific and hydrologic theory given in the period before the field course to solve hydrological questions in the field. The objectives include planning and making decisions about research strategies, learning to make relevant measurements of all the components of the hydrological cycle (surface water, ground water storage, soil moisture, vegetation, and the atmosphere) and use these measurements to make realistic qualitative and quantitative interpretations regarding the hydrological processes and conditions in the field and their relation to local and regional issues related to water resources.

Inhoud vak
This course covers the practical side of hydrological research through application of geological and hydrological knowledge to solve the water balance of target areas and to study water quality issues. Students are first familiarized with the geology and hydrology of coastal areas in Portugal and with the relations between geology, land use, vegetation and water (quantity and quality). The focus then shifts to hydrogeological mapping, the collection of field data and their integration to develop qualitative and quantitative conceptual hydrological models for solving the water balance and to address water quality processes and concerns (salinization, agricultural pollution). The field work will be carried out in an area with relatively high precipitation. The relation between hydrology and geology, vegetation, land use, and climate will be studied and the practical and societal aspects will be addressed. Students perform an independent catchment and groundwater hydrology study. The field period is immediately followed by three weeks during which collected field data are analyzed and reported in the form of an individual scientific paper.

Onderwijsvorm
The course is subdivided in two parts. Before the fieldwork a preparatory workshop will be organised. In the fieldwork region, each group will be assigned a study catchment in which a hydrological observation network (surface water, ground water, meteorology, etc.) will be installed. Students are expected to work independently and make their own decisions regarding planning and research strategy. Data processing, analysis and modelling are an integral part of the field course to scale up the measurements and link their findings to water resources issues in the region. An individual scientific paper-style report will be written in Amsterdam during the final part of the course. Staff members will be present during the whole course period for supervision and for consultation by students.

Toetsvorm
Execution of field campaign
Publication of scientific paper on results

Literatuur
Boris M. van Breukelen, Michel M.A. Groen, Koos Groen, Ko van Huissteden, Richard A.M. de Jeu, Vincent E.A. Post, Jaap Schellekens and Maarten J. Waterloo (2014). Handbook for Field Hydrological Measurements. VU University Amsterdam.

Vereiste voorkennis
Admission to this field course is granted to students who have been admitted to the Hydrology MSc Programme. Furthermore, students must have completed the course Measuring Techniques in Hydrology and, before mid-April, must have passed at least two of the courses Catchment Response Analysis, Groundwater Processes, Water Quality and Unsaturated Zone and Near Surface Hydrological Processes.

Aanbevolen voorkennis
The student should have a good general knowledge of the subjects discussed in the basic theoretical courses M.Sc. Hydrology master, i.e. Catchment Response Analysis, Ecohydrology, Groundwater Processes, Water Quality, Unsaturated Zone and Near Surface Hydrological Processes. Participants will need to work with GIS for analysing and displaying spatial spatial data and will need to be familiar with field methods.

Doelgroep
First year MSc Hydrology Programme students

Overige informatie
The course coordinator will send you an e-mail asking for information about your participation in this course in January. Besides registering for this course via the VUnet portal for this course please respond to the e-mail request of the coordinator before 31 January. The course is partly subsidized by the faculty and the students are obliged to pay for the other part of the course (travel, residence costs, etc.).

From Source to Sink: Chemical and Physical Cycles

Vakcode	AM_450146 ()
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. M. ter Voorde
Examinator	dr. M. ter Voorde
Docent(en)	dr. M. ter Voorde
Lesmethode(n)	Werkcollege, Computerpracticum
Niveau	400

Doel vak
After having attended this course, the student should have gained knowledge and understanding about
- The interplay of (physical) mechanisms responsible for landscape evolution
- The relative importance and the mutual interaction between these processes
- The methods to put constraints on these processes from geological

data, and the strength and limitations of these methods
as well as the skills to
- Read and critically assess significant literature about these subjects
- Actively participate in (oral) discussions about these subjects
- Judge research methods applied on this subject critically on their merits and weak points
- Compare and/or combine the results of different studies.

This implies that the course is not mainly focused on acquiring new knowledge, but especially on using, integrating and reflecting on the things you may have learned before.

Inhoud vak
This course deals with the parameters regulating the production, transfer and storage of sediments and solutes from their sources to their sinks, addressing short-term and long-term landscape evolution and sustainability. It covers the linked processes of tectonics, weathering, erosional systems (fluvial, glacial, marine) and climate changes, including ‘real-world’ examples on the SE Netherlands, the Ardennes, the Pyrenees and western Scandinavia, as well as the methods to constrain these processes (e.g. provenance studies and thermochronology). Lecturers from a variety of disciplines will teach the student how to view these topics from various backgrounds.

Onderwijsvorm
Lectures, exercises, literature study. A selected set of papers will be used for a 'PhD- defense'-role play. In addition, numerical modelling of topography development will be carried out by the students.
Aantal contact-uren: 45 (inclusief tentamen)

Toetsvorm
Exam (45%), essay (20%), computer-practicum report (10%) PhD-defense-"game"(25%).

Literatuur
• Book:
Tectonic Geomorphology, D.W. Burbank and R.S. Anderson, 2nd edition, 2011. John Wiley & Sons, 320 pp.

Additional papers, which will be made available via Blackboard

Doelgroep
Masterstudents GBL, Earth Sciences Solid Earth, Earth Sciences AEG, Earth Sciences Paleoclimate and Geo-ecosystems

Geothermal Energy

Vakcode	AM_450409 ()
Periode	Periode 5
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. M.P. Bokhorst
Examinator	dr. M.P. Bokhorst
Lesmethode(n)	Hoorcollege, Computerpracticum
Niveau	500

Doel vak

• To provide students with an overview of the current status and future outlook of geothermal exploration and production (heat/cold and electricity)
• To assess its impact in the energy-transition challenge, being a major alternative source for renewable energy.
• To provide insight into the energetical and economical aspects of different ways to supply thermal energy to buildings and processes.
• To review main categories of operational geothermal systems, the governing processes and relevant boundary conditions, linking hydrogeology to subsurface understanding
• To assess exploration concepts of geothermal prospecting and see how they can be applied to future subsurface analysis and energy supply prediction

An additional practical aim is to improve your communication and writing skills.

Inhoud vak

This course provides a comprehensive overview of existing systems that are used to supply thermal energy to buildings and/or industrial processes. The course starts with a general introduction to the history of geothermal exploration and production, what kind of geothermal systems exist, and how these are linked to particular subsurface and economical conditions. In addition it is explained what benefits of geothermal energy exist compared to other energy resources. Subsequently different aspects are explained in more detail. We will first
concentrate on the demand side, by showing how the heat and cold demand of a building can be provided by different types of energy systems and how the economical aspects of the different options relate. Later on we will focus on the hydrogeological parameters that contribute to successful geothermal systems. This is achieved through a review of several such systems, including borehole heat exchangers (closed loop systems), aquifer thermal energy storage (ATES or open loop systems) and systems for the production of deep geothermal heat for heating and/or electricity production (enhanced geothermal systems). Special emphasis is placed on the relation of subsurface conditions and operational excellence.
During the course the students are put in the role of consultants that have to choose an optimal solution for the customer. A business case is build in which different geothermal options have to be considered and compared to a conventional solution for climate control in the buildings concerned.

Onderwijsvorm

The course uses two different methods:
Oral lessons in the form of lectures and tutorials/seminars (distributed equally) where various topics are presented by the lecturer and discussed in common with the students. Students must be aware that the content of this course is difficult to find in one-two textbooks. Therefore, understanding the handouts is essential. Our advice is to attend the oral lessons during class hours. Further students are expected to read and present material from selected papers in a short presentation and abstract.
Practical lessons: this course includes a number of practical exercises and a few case studies. Exercises and case studies will be worked out individually and in small groups and discussed in class. The rule of

thumb: this is individual work, unless otherwise specifically noted.

Toetsvorm
The final mark is made up of assignments (10%), a presentation, an excursion(10) and a 1-page abstract of relevant paper(s) (10%) and case studies (70%).
The practicals and case studies will cover the topics presented during the course.

Literatuur
All materials will be digitally provided through Blackboard

Vereiste voorkennis
To facilitate a rapid in- depth study at MSc level, students are required to know in advance basic notions of hydrogeology (groundwater flow, impact of wells on hydraulic head) which were already studied during their BSc curriculum. Furthermore sufficient knowledge of mathematics and MS Office (Excel) is required.

Global Biogeochemical Cycles

Vakcode	AM_450332 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	prof. dr. G.R. van der Werf
Examinator	prof. dr. G.R. van der Werf
Docent(en)	dr. J. van Huissteden, dr. G.M. Ganssen, prof. dr. G.R. van der Werf, prof. dr. ir. J.W. Erisman, prof. dr. G.J.A. Brummer
Lesmethode(n)	Computerpracticum, Hoorcollege
Niveau	400

Doel vak
To understand and quantify the role of biogeochemical cycles (Carbon, Nitrogen, Phosphorus, Water) in the Earth system.

Inhoud vak
The course starts with an overview of the major global biogeochemical cycles, their role in the Earth system, and how they are modified by humans. The main subject is exchange of C, N, P, and S between the soil, water, atmosphere, and biota on global and local scales in different climatic zones (tropics, temperate, boreal and arctic zone) and environments. We address the relation of biogeochemical cycles with the climate system. Each week consists of two lectures where the first one serves as an introductory lecture and the second a more in-depth view of a theme in global biogeochemical cycles. The themes include: 1) the global terrestrial carbon cycle, 2) forests, 3) the nitrogen cycle, 4) the oceanic carbon cycle, 5) oceanic cycles of N, P, and S, 6) wetlands, and 7) disturbances including deforestation and forest fires.

Onderwijsvorm

12 Lectures, assistance with essay writing

Toetsvorm
Written exam (50%) and essay (50%)

Literatuur
W.H. Schlesinger: Biogeochemistry: An analysis of Global Change, 3th edition (Academic Press).
Lecture notes and additional literature will be made available during the course.

Doelgroep
MSc students Earth Sciences, Hydrology, Environment and Resource management

Groundwater Microbiology and Geochemistry (Geomicrobiology)

Vakcode	AM_450132 ()
Periode	Ac. Jaar (september)
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	U. Nunes da Rocha
Examinator	U. Nunes da Rocha
Niveau	400

Doel vak
At the end of this interdisciplinary course, students will be able to describe and explain:
- Aspects of the growth and cellular functioning of microorganisms
- The role of microorganisms in nutrient cycli
- Important microbial processes in polluted and pristine groundwater ecosystems
- The dependency of microbial presence and activity on environmental conditions
- Modern methods in microbial ecology
Students can relate the obtained knowledge to hydrology.

Inhoud vak
Theory will consist of:

Introduction to environmental microbiology:
- Microbial growth, metabolism and kinetics in relation to environmental conditions.
- Types and diversity of micro-organisms in groundwater ecosystems.
- Interactions between micro-organisms.
- Basics of molecular microbiology; overview of modern techniques in microbial ecology and biogeochemistry.

Impact of microbiological processes on hydrochemistry:
- Microbial contribution to important biogeochemical processes and nutrient cycles.
- Microbial mediated mineral dissolution and precipitation.

Degradation of organic contaminants in groundwater:

- Biodegradation, bioremediation and "natural attenuation" of pollution.

Onderwijsvorm
~90 hours of guided self-study (the student will study the book Brock Biology of Microbiology, on basis of 5 modules containing instructions and about 20 questions per module), 70 hours for essay writing. After each of
the five modules, the student and lecturer discuss the answers (~1 h per module).

Toetsvorm
Written essay (70% of final mark) on a geo-microbiological subject, linked to the interests of the student and general course content. Oral discussion on the essay and studied text (30%).

Literatuur
Michael T. Madigan, John M. Martinko, Kelly S. Bender, Daniel H. Buckley, David A. Stahl (2014), Brock biology of microorganisms, 14th edition. Pearson Higher Education. ISBN-3: 9781292018317 (about 85 euro) [you may also use the 13th edition]

Weber K.A. et al.(2006), Microorganisms pumping iron: anaerobic microbial iron oxidation and reduction. Nature Reviews in Microbiology, 4, p. 752-764.

Handout for guided self-study (via lecturer).

Intekenprocedure
The course can be started at any time during the academic year, in consultation with the coordinator

Overige informatie
This course is an elective option for master students in Hydrology. The course is also open to students in the masters Biology and Earth Sciences. Part of the content can be adapted to fit the interest and educational background of the student. Students are advised to contact the coordinator before starting.

Groundwater Processes

Vakcode	AM_1164 ()
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. ir. Y. van der Velde
Examinator	dr. ir. Y. van der Velde
Lesmethode(n)	Werkcollege
Niveau	400

Doel vak
The objective of the course on Groundwater Processes is to gain knowledge and insight in the terminology and theory of groundwater hydraulics, including its mathematical notation and physical meaning.

Inhoud vak
The movement of groundwater through the subsurface is a fundamental part of the hydrological cycle. In this course, you will get acquainted with the fundamental hydraulics of groundwater flow. You will get profound insight into fundamental hydrological concepts related to groundwater flow and its mathematical notation and solutions. The application of this knowledge will be illustrated using some basic groundwater flow modelling exercises.

Onderwijsvorm
The course consists of a set of lectures supplemented with practicals.

Toetsvorm
Written examination

Doelgroep
Hydrology MSc students and other earth sciences related MSc programs

Integrated Modeling in Hydrology

Vakcode	AM_1165 ()
Periode	Periode 3
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. H. de Moel
Examinator	dr. H. de Moel
Docent(en)	dr. P.J. Ward, dr. H. de Moel
Lesmethode(n)	Werkcollege, Computerpracticum
Niveau	400

Doel vak
The objectives of this course are for the students to:
- get acquainted with the wide range of modeling tools used in integrated hydrological studies
- understand the type of questions that can be answered using such tools
- acquire hands-on modelling skills and gain experience with some commonly used analytical programs (Matlab, GIS, Excel)

Inhoud vak
The course is set up with a limited amount of lectures and two large exercises. In these exercises the students will set up and apply their own models from start to finish. The first exercise concerns a spatial rainfall-runoff model using publicly available data sources. This model will be used to simulate river discharge under current and future climatic conditions, and results will be related to water resources availability and associated measures. The second exercise is a flood risk assessment where hazard, exposure and vulnerability will be combined to estimate flood risks. Using the model, measures will be evaluated on their risk reducing effect.

Onderwijsvorm
There will be a limited amount of lectures (in mornings) as the focus is on the development of the two exercises. Practical sessions are

scheduled throughout the period where staff will be available to help with technical questions and to help start up the model development. The rest of the time students will work on their models, analyses and reporting themselves.

Toetsvorm
Assessment will be done in the form of a report and a presentation related to the assignments.

Literatuur
Relevant course reading material (papers, reports) will be provided via blackboard

Doelgroep
Hydrology MSc students and other earth sciences related MSc programs

Master Thesis Hydrology

Vakcode	AM_1170 ()
Periode	Ac. Jaar (september)
Credits	36.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. H. de Moel
Examinator	dr. H. de Moel
Lesmethode(n)	Werkcollege
Niveau	600

Doel vak
To conduct a research project in the scope of the MSc program Hydrology. The student will learn to develop his/her own research question, plan this research, collect data, perform analyses, draw proper findings and report on this.

Inhoud vak
The student will set up, execute and report on a research project on a hydrological topic. This research and report serves as the final activity of the student within the MSc program where knowledge and skills obtained during the program are integrated and demonstrated by the student.

Onderwijsvorm
This is course consist of self-study by the student, under guidance of a supervisor from the staff related to the MSc hydrology.

Toetsvorm
Written report/paper and oral presentation.

Vereiste voorkennis
A minimum of 36 ects is required before starting with this thesis project.

Doelgroep
MSc Hydrology students

Measuring Techniques in Hydrology

Vakcode	AM_1168 ()
Periode	Periode 5
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. R. Lasage
Examinator	dr. R. Lasage
Lesmethode(n)	Werkcollege, Computerpracticum, Practicum
Niveau	400

Doel vak
The objective of this course is to familiarize students with measurement methods and techniques from different disciplines, that are commonly used in hydrology and related environmental sciences. The course is divided into 3 modules, in four weeks. The three parts are focused on measuring hydrological processes: Module 1 focuses on measuring techniques to understand and quantify the basic processes in the water balance and hydro chemistry, such as measuring discharge and rainfall. Module 2 focuses on using remote sensing to measure variables such as soil moisture and vegetation characteristics. Module 3 focuses on measuring the effects from hydrological processes (water availability and quality, and extremes such as floods) on people and the economy. For this, students will learn how to design, conduct, and statistically analyse a household survey to quantify economic impacts.
At the end of the course the student should be able:
1. to select the appropriate field measurement methods and techniques to measure hydrological processes and impacts on society;
2. to implement the methods and techniques, including equipment operation;
3. to analyse, evaluate and interpret the results, using computer models and statistical methods;
4. to carry out the final integrating fieldwork, which directly follows this course, and other research projects independently.

Inhoud vak
Module 1. Hydrological field tools
This part of the course deals with a broad range of field measurement aspects of hydrological studies. Practical research experience is gained through a study of the water balance and hydrochemistry of the field area. This includes instructions in geohydrological, meteorological, and hydrochemical measurement techniques that are commonly used in surface and groundwater movement studies and in water quality investigations. Spatial data collection and processing methods are practiced through the use of portable geographic information systems. Key course subjects are installation of hydro-meteorological equipment for measuring rainfall, temperature, water level and discharge, soil and aquifer permeability measurements, soil moisture and tension measurements, water sampling and chemical analysis, datalogger programming, data processing and analyses.
Module 2. Remote sensing
This module will make the student more familiar with remote sensing and the main objectives of this module are: (i) to understand the fundamental characteristics of electromagnetic radiation and how this

interacts with vegetation, soil, rock and water; (ii) to understand and master the methodology behind a large variety of remote sensing applications related to land surface observations, including a clear understanding of the limitations of these observations; (iii) to develop practical computer skills to use remote sensing products in environmental studies. During the lectures the physical basics and mathematical principles of remote sensing will be discussed. During the practical exercises we will use a suite of remote sensing-derived environmental data from satellites to derive information on geology, soil, water, and vegetation. The focus is on the integration of several remote sensing techniques in hydrological analysis and modeling
Module 3. Measurement of economic values of water
The discipline of environmental economics has developed stated preference techniques whereby non-market values of water can be estimated, such as those related to water quality, amenities of water and the control of water risks. This module will make students familiar with these techniques, such as contingent valuation and choice experiment methods that elicit water related values using surveys of households. During the lectures these techniques as well as the design of surveys will be discussed. Moreover, students will get hands on experience with data collection by conducting a stated preference survey in the field. In a practicum class students will learn to analyse the data they collected using statistical methods.

Onderwijsvorm
Lectures, practicals, field practicals.

Toetsvorm
Written exam, assignment report, participation during field practical.

Literatuur
Will be provided by the teachers

Modern Climate and Geo-ecosystems

Vakcode	AM_1124 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. G.M. Ganssen
Examinator	dr. G.M. Ganssen
Docent(en)	dr. G.M. Ganssen
Lesmethode(n)	Excursie, Werkcollege
Niveau	400

Doel vak
In the first part the course gives an introduction of modern atmospheric and oceanic processes which form an important basics for the reconstruction of the climate of the past. Next to important basic parameters which trigger the modern circulation of both spheres, atmosphere and oceans, the main circulation paterns will be discussed together with the implications for the global climate.
In the second part the modern ocean changes and their implications for the geoecosystems will be discussed. Together, this will form the basic

understanding of processes which govern changes in the geological past.

Inhoud vak
-the basic parameters and properties for atmospheric and ocean processes leading to the formation and circulation of air and water masses
- characterization of climatic regions of the world from the poles to the tropics
- special features of the climate systems like the monsoon, ENSO and NAO systems
- the effect of ocean changes on geoecosystems now and in the recent past

Onderwijsvorm
Lectures and workshops, literature reading, oral and written presentations by the students and discussing the results and quality of the presentation

Toetsvorm
Written exam after week 2 about the basics (50% of the grade)
oral and written presentation of a topic (second part of the course, 50% of the grade)

Literatuur
Lecture notes (powerpoints of the presentations by the teacher), selected papers and Ruddiman, W.F., 2013. Earth's Climate: past and future.W.H. Freeman and Company New York.

Vereiste voorkennis
Some basic knowledge of the climate system, interest in climate change

Doelgroep
Students from the geo and environmental study areas

Intekenprocedure
Subscription via BB

Reflection Seismic for Geologists

Vakcode	AM_450170 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. P.J.F. Verbeek
Examinator	dr. P.J.F. Verbeek
Lesmethode(n)	Werkcollege, Computerpracticum
Niveau	500

Doel vak
The participant is expected to collect sufficient understanding of the fundamentals and the limitations of the applications of reflection seismology as a tool to predict the structure and geology in the shallow to deeper (100's to 1000's of metres) subsurface. The aim is to derive the evolution of sedimentary basins and underlying crust by using seismostratigraphic and structural interpretation of seismic

lines. In particular, the participant will learn:
the application of technical and methodological principles of reflection seismology to real situations;
the basic principles linking geology and reflection seismology, including an introduction to petrophysics;
seismic workstation skills for seismic interpretation, and
how to extract reliable information on sequence stratigraphy and structure from seismic reflection and well log data.

Inhoud vak
Assuming a basic knowledge of the principles of reflection seismology, this course provides a modular programme with hands-on experience on interpreting seismic lines and integrating data from well logs, principles and interpretation of reflection seismic data and geology. Special attention will be paid to pitfalls in data acquisition, processing and interpretation. The course will use in part similar methodologies used in hydrocarbon exploration and development.
The course is constructed in 5 parts:
Part 1 Introduction to seismics. The introduction will cover the technical and methodological broadband principles of reflection seismology. Note that this section will build on already existing Applied Geophysics course knowledge;
Part 2 Introduction to interpretation. Students will learn how to interpret basic geological features, such as strata relationships, faults and folds as well as the reliability of seismic interpretation at various scales;
Part 3 Seismic sequence stratigraphy. Learning seismostratigraphy will mean in practice how to extract stratigraphic, sedimentological and basin evolution information from seismic data. This information is used as a tool in exploration and basin analysis to derive regional analysis of sedimentary basin-fills with a view towards constructing models for gross lithology prediction. It is recommended that students remind themselves the principles and methodology of sequence stratigraphy, already acquired during their BSc courses;
Part 4 Seismic structural interpretation. This section will provide students with the knowledge of interpreting deformation structures at various scales;
Part 5 Interpretation on workstation. This section gives the students the opportunity to work on case studies by using standard workstation methodologies for seismic interpretation. Students will learn how to handle, visualize and interpret 2D and 3D seismic data using a standard industrial software package;
Part 6 Integrating wells with seismics for seismostratigraphy, deriving basin evolution. The section will give students the chance to start from reflection seismic and correlative well interpretation to derive the evolution of sedimentary basins at local and regional scale.;
Part 7 Advanced seismic interpretation This section will give students the opportunity to work with advanced methodologies of seismic interpretation specific for petroleum exploration.

Onderwijsvorm
The course uses two different methods:
Oral lessons, where the lecturer presents various topics. Students must be aware that the content of this course is difficult to find in one-two textbooks. Therefore, understanding the handouts is essential. Our advice is to attend the oral lessons during class hours.
Practical lesson; the bulk of this course is made up by a large number of practical exercises and a few case studies. You will have to hand in at the end of the course a part of these for evaluation

purposes, as noted by the staff. Make sure you understand which are those exercises and case studies needed for evaluation. The thumb rule: this is individual work, unless otherwise specifically noted.

Toetsvorm
The final mark is made up by 50% the practical exercises and case studies handed in at the end of the course and 50% the final examination. The practical exercises and case studies must be handed in no later than one day prior to the final examination. The exam will cover the topics presented during course. It is typically organized in blocks of questions from every part of the course AND 2 - 5 data sets (seismic lines) which you will be asked to interpret in terms of specific issues.

Literatuur
All materials will be digitally provided through Blackboard.

Overige informatie
Teaching staff: John Verbeek

Scientific Writing in English

Vakcode	AM_471023 ()
Periode	Periode 2, Periode 5
Credits	3.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	M. van den Hoorn
Examinator	M. van den Hoorn
Lesmethode(n)	Werkgroep
Niveau	400

Doel vak
The aim of this course is to provide Master's students with the essential linguistic know-how for writing a scientific article in English that is well organized, idiomatically and stylistically appropriate and grammatically correct.
At the end of the course students
know how to structure a scientific article;
know what the information elements are in parts of their scientific article;
know how to produce clear and well-structured texts on complex subjects;
know how to cite sources effectively;
know how to write well-structured and coherent paragraphs;
know how to construct effective sentences;
know what collocations are and how to use them appropriately;
know how to adopt the right style (formal style, cohesive style, conciseness, hedging)
know how to avoid the pitfalls of English grammar;
know how to use punctuation marks correctly;
know what their own strengths and weaknesses are in writing;
know how to give effective peer feedback.

Final texts may contain occasional spelling, grammatical or word choice

errors, but these will not distract from the general effectiveness of the text.

Inhoud vak
The course will start with a general introduction to scientific writing in English. Taking a top-down approach, we will then analyse the structure of a scientific article in more detail. As we examine each section of an article, we will peel back the layers and discover how paragraphs are structured, what tools are available to ensure coherence within and among paragraphs, how to write effective and grammatically correct sentences and how to choose words carefully and use them effectively.

Topics addressed during the course include the following:
Structuring a scientific article
Considering reading strategies: who is your readership? How do they read your text? What do they expect? How does that affect your writing?
Writing well-structured and coherent paragraphs
Composing effective sentences (sophisticated word order, information distribution).
Arguing convincingly – avoiding logical fallacies
Academic tone and style: hedging – why, how, where?
Using the passive effectively
Understanding grammar (tenses, word order, etc.)
Understanding punctuation
Referring to sources: summarising, paraphrasing, quoting (how and when?)
Avoiding plagiarism
Vocabulary development: using appropriate vocabulary and collocations

Onderwijsvorm
Scientific Writing in English is an eight-week course and consists of 2 contact hours a week. Students are required to spend at least 6 to 8 hours of homework per week. They will work through a phased series of exercises that conclude with the requirement to write several text parts (Introduction, Methods or Results section, Discussion and Abstract). Feedback on the writing assignments is given by the course teacher and by peers.

Toetsvorm
Students will receive the three course credits when they meet the following requirements:
Students hand in three writing assignments (Introduction, Methods, Discussion)
Students get a pass mark for all writing assignments;
Students provide elaborate peer feedback (Introduction, Methods, Discussion, Abstract);
Students attend at least 7 out of 8 sessions;
Students are well prepared for each session (i.e. do all homework assignments);
Students participate actively in class;
Students do not plagiarise or self-plagiarise.

Writing assignments:
1. If students have a BSc thesis in a traditional thesis form (e.g., 20+ pages) and written in English, they may use this for the writing assignments.
2. If students have a BSc thesis in a traditional form (e.g., 20+ pages) written in another language than English, they may use this for

the writing assignments.
3. If students have written a paper or report in English that's not already in article form, they may use this for the writing assignment.
4. If students are working on their MSc thesis or internship report when taking Scientific Writing in English, they may use this for the writing assignments. They will have to notify their supervisor to make sure that they won't be accused of self-plagiarism.
5. If students cannot or do not wish to use any of the above-mentioned texts for the writing assignments (1-4), they are expected to do a limited Literature Review on a topic in their field of research, using at least 5 articles.

Students are not allowed to use the following texts for the writing assignments:
1. A BSc thesis written in English that's already in article form.
2. A MSc thesis written in English that's already in article form (and that has already been marked).
3. An internship report written in English that's already in article form (and that has already been marked).
4. A paper or report written in English that's already in article form.

Literatuur
Effective Scientific Writing: An Advanced Learner's guide to Better English, 4th edition (February 2016) (A. Bolt & W. Bruins, ISBN 978 90 8659 617 1). VU bookstore: €27.95.

Doelgroep
This course is only open to students of the two-year Master's programmes of the Faculty of Earth and Life Sciences. These students are only eligible to the course if they have already conducted scientific research (e.g. for their Bachelor's thesis) or if they will be working on a research project when taking Scientific Writing in English.

Overige informatie
- To do well, students are expected to attend all lessons. Group schedules are to be found at rooster.vu.nl and on Blackboard.
- A VUnet registration for this course automatically gives access to the corresponding Blackboard site. Group registration only takes place via Blackboard (general groups: registration by students following FALW programmes offering this course; groups assigned to specific studies: registration through programme and course coordinator).
- Make sure Scientific Writing in English does not overlap with another course.
- If you have registered for a group in Blackboard, you are expected to attend all sessions (eight). If you decide to withdraw from the course, do so in time in VUnet. This will avoid a 'fail' on your grade list for not taking part in this course and allows other students to fill in a possible very wanted group spot.
- For specific Blackboard matters concerning this course, please contact blackboard.beta@vu.nl.
- Full time students with their main registration at VU will be given preferential treatment for placement in this course. For secondary students proof of enrollment is not a guarantee of placement.

Unsaturated Zone and Near Surface Hydrological Processes

Vakcode	AM_450021 ()

Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	S.F. Stofberg MSc
Examinator	S.F. Stofberg MSc
Lesmethode(n)	Computerpracticum, Werkcollege
Niveau	400

Doel vak
The main objective of this course is to provide basic insight into the hydrological processes operating within the unsaturated zone as a whole, and near the surface in particular. This hydrological knowledge forms the basis for determining recharge rates, plant available water, runoff ratios, etc. It requires fundamental theoretical and practical knowledge on soil properties and the physics of soil water movement.

Inhoud vak
At the end of this course students should be able to:
• Discuss soil characteristics in relation to soil water movement and storage
• Discuss the processes that determine the storage and movement of water in the unsaturated zone, and how this affects and is affected by other hydrological processes
• Describe the various measurement techniques to determine the storage and movement of water in and through the unsaturated zone
• Produce a simple hydrological model to analyse and describe the movement of water through the unsaturated zone and analyse how this is affected by soil properties
• Discuss the objectives, advantages and limitations of hydrological models for the unsaturated zone
• Have obtained an awareness of how vegetation and land management affect soil erosion and water quality

Onderwijsvorm
The course consists of a set of lectures supplemented with practicals.

Toetsvorm
Written examination.

Doelgroep
Hydrology MSc students and other earth sciences related MSc programs

Water Economics

Vakcode	AM_1167 ()
Periode	Periode 4
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. J.E. Blasch
Examinator	dr. J.E. Blasch
Docent(en)	dr. P.J.H. van Beukering, prof. dr. W.J.W. Botzen, dr. J.E. Blasch

Lesmethode(n)	Werkcollege, Hoorcollege, Practicum, Computerpracticum
Niveau	400

Doel vak
The overarching objective of this course is to familiarize students with the economic analysis of water related problems and solutions. After following this course, students should be able to judge how well certain policy instruments and institutional arrangements perform in terms of effectiveness, efficiency and the sustainability of water management. More specifically, after having participated in this module, students should be able to answer the following questions:
- What is the fundamental nature of water related problems from an economic perspective, in relation to notions like externalities, public goods and free riding, and what does this imply for the feasibility of (easy) solutions?
- How are water resources and the economy and society interlinked, and what are the implications of such linkages for sustainable water use?
- What are the guiding principles of economic analyses of solutions for water related problems, such as hydro-economic modelling?
- How to characterize and measure economic values of water?
- Which economic policy instruments are available for water management, and what are their (dis)advantages?
- How to conduct cost-benefit analysis (CBA) to guide the design of water management strategies and what are the critical and debatable assumptions that underlie a CBA?

Inhoud vak
The course Water Economics aims to provide methodological skills for non-economic students to analyze the drivers behind and effects of water related problems and solutions around the world, in order to move towards a sustainable use of our valuable freshwater resources. Particular topics include evaluating the costs and benefits of alternative water policies to deal with water pollution, river and groundwater ecosystem restoration, water quantity and water-related hazards, such as floods, as well as integrated hydro-economic modelling and water markets and pricing.

The course has been designed to balance learning and training skills related to both theory and applied (quantitative) methodologies. Moreover, the students will apply their newly developed skills to relevant case study areas. Each week will center around a main specific economic topic and/or method, allowing students to learn specific skills while practicing them on specific water topics.

Onderwijsvorm
Lectures, Practicum, Computer lab.

Toetsvorm
Written exam and assignment.

Literatuur
Readings will be announced on blackboard.

Doelgroep
Hydrologist, Water Science.

Water Management

Vakcode	AM_468023 ()
Periode	Periode 1
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. P. Scussolini
Examinator	dr. P. Scussolini
Docent(en)	prof. dr. J.C.J.H. Aerts, dr. R. Lasage, dr. H. de Moel
Lesmethode(n)	Hoorcollege, Computerpracticum
Niveau	400

Doel vak
The objective of this course is to understand how water related processes such as floods and droughts influence our society and what role water management plays in addressing and tackling these issues. This course aims to provide students a multi-disciplinary understanding of water management, including the physical dimensions of the hydrological cycle and coastal proceses,
the policy, law and long term trends such as climate change and land use change. It puts emphasis on the uncertainty of future trends and how risk management methods can be helpful for water managers for dealing with these uncertainties.

Key goals for students to reach at the end of the course are:
• To understand the complexity of various water related issues (e.g. scarcity, floods, and droughts) and to assess the economic and social impacts
• To learn what kind of measures can be taken to alleviate water related problems and what kind of positive and negative effect these measures have on different users.
• To be able to systematically approach a complex and integrated water related issue and properly interpret data and information about this issue.

Inhoud vak
Water managers see themselves confronted with a continuous stream of increasingly credible scientific information on the potential magnitude of population growth, economic activities and climate change that increase the risk related to the earth hydrological system. It is expected that floods and droughts will increasingly affect societies and economies and new approaches in water management are needed to deal with these challenges. Furthermore, developing adequate water policies that can be used in practice is a difficult issue and is the result of a complex and long-lasting process from the national through to the local level. In this process, the science of the water- and socio-economic systems can play an important role by supplying policy makers with answers on e.g. the socio-economic effects of floods and droughts. Uncertainty in future trends further puts new challenges to water management and risk based techniques can be helpful in dealing with these uncertainties. Finally, water management increasingly needs to cooperate with spatial planners, especially in large cities, to address increasing risk from storm surges and sea level rise.

Onderwijsvorm

This course consists of several sessions going into different subjects related to water management. These sessions will consist of lectures by the professors with interactive discussion; two practical assignments, and student presentations. Apart from these sessions, you will team up in pairs of two students to write papers on water related issues and adaptation in cities, which will be peer-reviewed by other students.
Activity Hours
1 Attending and contributing to sessions (12 times 3 hrs) 36 hours
2 Readings associated with lectures 28 hours
4 Paper: literature review (32 hours), writing (24 hours), peer review (8 hours) 64 hours
5 Exam preparation 40 hours
TOTAL 168 hours

Toetsvorm
Written exam (50%), essay (40%) and peer-review (10%)

Literatuur
The literature for this course consists of various academic papers and chapters. These papers will be published 3 days before the lecture

Doelgroep
MSc students Environment and Resource Management (ERM), MSc Hydrology; Earth Sciences and Economics(ESE).

Water Quality

Vakcode	AM_1166 ()
Periode	Periode 2
Credits	6.0
Voertaal	Engels
Faculteit	Fac. der Aard- en Levenswetenschappen
Coördinator	dr. J.E. Vonk
Examinator	dr. J.E. Vonk
Lesmethode(n)	Werkcollege
Niveau	400

Doel vak
The objective of the water quality course is to provide students with a basic understanding of the landscape controls on water chemistry and quality. More specifically, the student will at the end of the course:
• have acquired a qualitative and quantitative understanding of biogeochemical processes in the soil that influence the chemical composition of water;
• understand how the chemical composition of water changes within the hydrological cycle: from precipitation, to groundwater to surface water;
• understand, describe and utilize techniques for assessing water quality, and be able to interpret hydro(geo)chemical data;
• be familiar with different types of pollutants affecting water quality, and understand how pollutants enter, move through, and interact with the hydrological system.

Inhoud vak

The quality and chemistry of water on Earth is a function of processes that occur in the human and natural environment. Water of sufficient quality is required for, for example, agricultural and domestic usage, as well as for healthy ecosystems. Knowledge on water chemistry is needed to study and interpret the quality of ground and surface water. The following course topics are included: water sampling, analysis of water and its constituents, parameters for assessing water quality (alkalinity, redox, nutrients), thermodynamics and kinetics of hydrogeochemical processes, isotopic composition of water and its constituents, how water properties change (reactive properties, dissolution, weathering, evaporation, mixing), carbonate chemistry, dynamics and transport of pollutants.

Onderwijsvorm
The course consists of a set of lectures supplemented with practicals.

Toetsvorm
Written examination

Doelgroep
Hydrology MSc students and other earth sciences related MSc programs