MSc Earth Sciences

Draft curriculum 2027–2028

Specialisations Earth System Dynamics and Global Environmental Change & Policy

Disclaimer

This document describes a draft curriculum for the MSc Earth Sciences as of the academic year 2027–2028. It is intended to give prospective and current students an indication of the direction of the programme. During the implementation phase some things such as course titles and exact content may still change. No rights can be derived from the information in this document. The Teaching and Examination Regulations (Onderwijs- en Examenregeling, OER) and the official study guide are leading at all times.
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About this document

From 2027–2028 onwards the MSc Earth Sciences will consist of two specialisations. The current specialisations Earth & Climate and Geology & Geochemistry are merged into one specialisation, called Earth System Dynamics (ESD), while the specialisation Global Environmental Change & Policy (GEC&P) continues in a slightly revised form.

This document contains two elements:

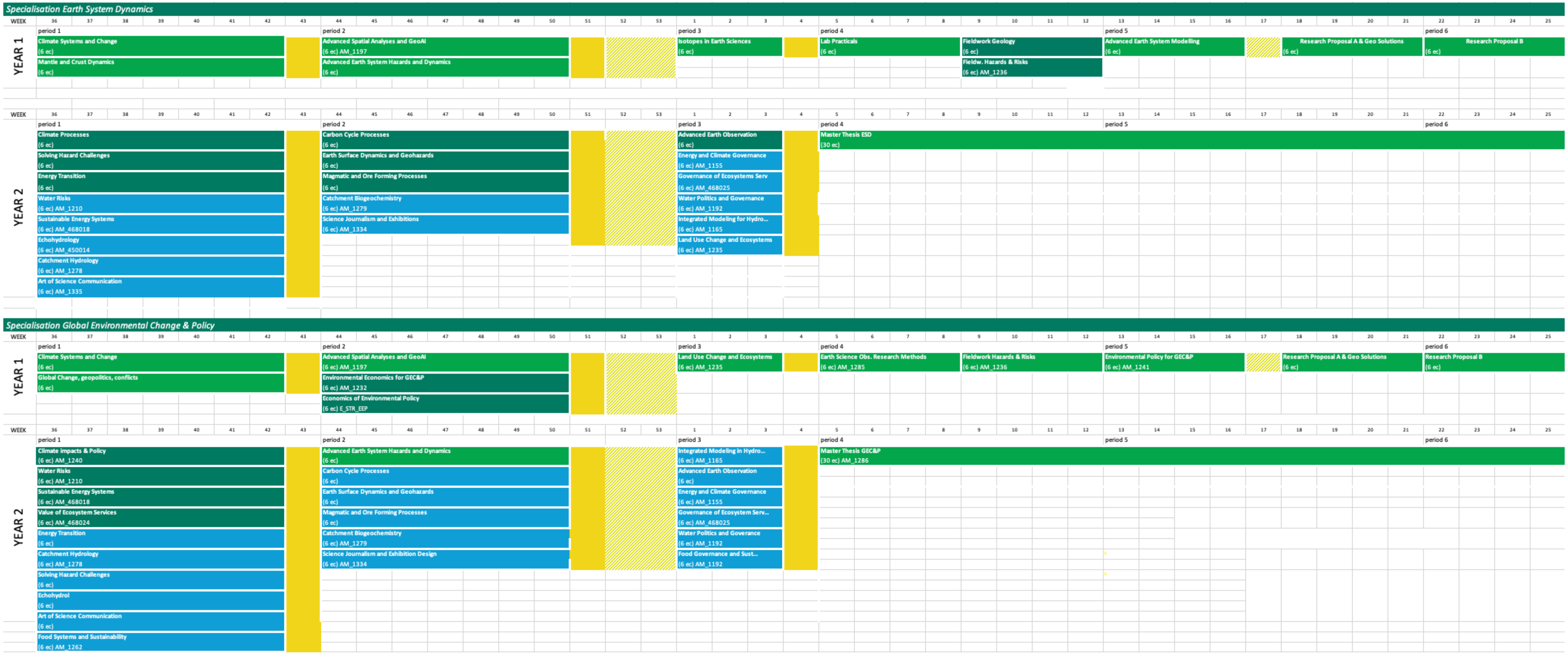
- the draft year schedules of both specialisations, showing the structure of year 1 and year 2 and the periods in which courses are scheduled;
- short descriptions of the new and substantially revised courses in the draft curriculum.

Descriptions of courses that already exist in the current programme, including the electives from the MSc Hydrology, the MSc Environment and Resource Management and the science communication courses are not repeated here. These can be found in the VU study guide: studiegids.vu.nl.

All courses in the draft curriculum have a size of 6 EC, with the exception of the thesis (30 EC). In the descriptions below, “compulsory” means that the course is a required part of the specialisation, and “constrained choice” means that students choose from a limited set of courses within their specialisation.

Draft year schedules 2027–2028

The schedules below show the draft structure of the two specialisations. The programme follows the regular VU 8-8-4-8-8-4 period structure. To accommodate full-time fieldwork, the two courses in period 4 are scheduled after one another rather than in parallel, each spanning four weeks. Colours indicate the type of course; courses without a course code are new or renamed and their codes will follow. Elective options and their scheduling are indicative.



Draft year schedules of the specialisations Earth System Dynamics (top) and Global Environmental Change & Policy (bottom), year 1 and year 2, academic year 2027–2028. Indicative and subject to change.

Short course descriptions

The courses of the Earth System Dynamics specialisation are organised in four learning paths: three thematic paths – Climate and carbon cycle, Geohazards, and Earth's interior dynamics and resources – and a fourth path covering skills and methods. Several of these courses are also part of, or available as an elective in, the Global Environmental Change & Policy specialisation; this is indicated per course.

Learning path: Climate and carbon cycle

The evolution of the climate and the carbon cycle in past, present and future is determined by the processes within, and the feedbacks between, geosphere, atmosphere, ocean, biosphere, land surface and cryosphere. Such processes include permafrost thawing, large-scale ocean circulation changes, shifts in the African monsoon, greenhouse gas release from wetlands, changes in ocean chemistry and ecosystems, and ice sheet melting. This learning path revolves around understanding climate and carbon cycle dynamics on timescales ranging from days to millions of years and from local to global scale, with a strong focus on the integration of observational work, modelling, proxy-based reconstructions, remote sensing and theoretical approaches.

Climate System and Change

6 EC · compulsory in Earth System Dynamics and in Global Environmental Change & Policy

This course aims to provide students with a solid understanding of the climate system, including the most important underlying physical processes, its overall characteristics and its variability. The focus is on the intimate links between the climate system, the large-scale circulation of ocean and atmosphere, the hydrological cycle and the carbon cycle. The course also addresses past climate change, regional impacts, changes in climate extremes and societal impacts.

Climate Processes

6 EC · constrained choice in Earth System Dynamics

This course provides in-depth knowledge of the functioning of the climate system and its components. The focus is on processes in the atmosphere and ocean, but the role of ice sheets, sea ice, vegetation and permafrost is discussed as well. It combines information from palaeoclimate proxy archives with modelling, (satellite) observations and theory.

Based on a selected number of climate processes, students investigate what can be learned by combining these different angles in terms of time, space and methodology. For example, students learn to bring together modern observations, proxy-based reconstructions, model outcomes and theoretical evidence to study the stability of the Atlantic meridional overturning circulation: how has it changed in the past, can we understand this, and what does that tell us about its future stability?

Carbon Cycle Processes

6 EC · constrained choice in Earth System Dynamics

This course provides in-depth knowledge of the basic functioning of the carbon cycle and its feedbacks with climate on shorter to longer timescales. The focus is on carbon cycle processes in soils, surface waters, ocean and atmosphere on local and global scales, covering different zones (tropical, temperate, boreal, arctic). It combines palaeoclimate proxy archives, modelling, and satellite, laboratory and field observations.

Based on a selected number of carbon cycle themes, students investigate what can be learned about them from a climate and carbon perspective, combining multiple angles in terms of time, space and methodology. On the topic of peatlands, for example, students learn how to use long-term palaeo-reconstructions and fundamental understanding to compare how past climate led to the stability of long-term carbon stores, and how current climate and land use practices may destabilise these stores in a pristine (boreal) and a disturbed (Dutch) setting.

Learning path: Geohazards

The Geohazards learning path focuses on understanding, analysing and mitigating natural hazards arising from interactions within the Earth system, at the interface between the atmosphere, the land surface and the deep Earth. It integrates topics and methods from climatology, hydrology, geomorphology, geology, tectonics and seismology into a coherent framework for studying natural hazards and their societal impacts. It addresses the physical and chemical processes involved in a wide range of geohazards and land surface dynamics, including flooding, landslides, forest fires, earthquakes and volcanic eruptions, and considers their spatial and temporal scales, process interactions, risks and impacts. Geohazard dynamics are explicitly linked to deep Earth processes, Earth surface processes, climate variability and change, and impacts on land use and hydrodynamic systems.

Advanced Earth System Hazards and Dynamics

6 EC · compulsory in Earth System Dynamics and in Global Environmental Change & Policy

This is mostly a descriptive and integrative course. Teaching methods comprise critical literature review and in-class demonstration of critical research paper evaluation and analysis. The course addresses processes in geohazards across climate, hydrology, geomorphology and tectonics, based on various types of hazards such as landslides, floods, droughts, wildfires, earthquakes and volcanic eruptions.

Students learn about interactions between atmosphere, land surface and deep Earth, about the spatial and temporal scales of hazards, and about links to land use, hydrodynamics and societal impacts. The course also discusses large-scale Earth system controls and multi-hazard, cascading and compound systems.

Solving Hazard Challenges

6 EC · constrained choice in Earth System Dynamics · elective in Global Environmental Change & Policy

This is a project-driven course that applies Earth science approaches to understanding and addressing natural hazards. Using real-world case studies and datasets, students investigate the physical processes that generate hazards, their links to geology, hydrology, climate and land use, and how these processes shape risks to ecosystems, infrastructure and society.

Students analyse challenges by integrating sedimentary, hydrological and socio-economic data, and tools such as GIS, remote sensing, spatial analysis and data science, to assess present and future vulnerability. The course also introduces event attribution approaches that quantify the relative roles of natural variability and human-induced environmental change in shaping hazard occurrence and impacts. Societal and economic dimensions are considered in the context of hazard assessment and decision-making, with contributions from societal and governmental partners and from industry, providing direct links to professional practice and potential career opportunities.

Earth Surface Dynamics and Geohazards

6 EC · constrained choice in Earth System Dynamics

This course fosters in-depth knowledge of the physical mechanisms driving land surface dynamics and geohazards from a process-based perspective. It builds on previous knowledge to discuss hydro-climatic extremes, geomorphological processes, tectonics, geodynamics and volcanology, and links these insights to sediment transport, landscape evolution and source-to-sink systems.

Students gain expertise in the interactions between vegetation and evolving landforms, including both palaeo-vegetation dynamics and present-day coupling between vegetation and surface processes, and in interactions between mantle dynamics, tectonics and surface topography. The course also covers non-linear processes, thresholds and tipping behaviour, multi-hazard and cascading systems, and the use of process-based modelling, observations (in situ and remote sensing) and theory, integrating these insights across spatial and temporal scales from single events to geological timescales. Project work focuses on modelling the evolution of the Earth's surface as the integrated expression of mantle dynamics, tectonics, climate and hydrology.

Learning path: Earth's interior dynamics and resources

This learning path focuses on the physical and chemical processes that control the formation and evolution of the Earth's interior, including core, mantle and crust, and their interaction with the surface. It integrates topics and methods from geology, tectonics, geodynamics, seismology, geochemistry and geochronology into a coherent framework for studying the dynamics of the Earth's interior and shallow subsurface. It addresses processes including mantle dynamics, plate tectonics, crustal deformation, earthquakes, and volcanic and magmatic activity, and considers their spatial and temporal scales, process interactions, and the formation of natural Earth resources, including (critical) raw materials and subsurface heat and storage potential. The learning path also links the Earth's interior material cycles and shallow subsurface resources to climate.

Mantle and Crust Dynamics

6 EC · compulsory in Earth System Dynamics

This advanced course focuses on the physical aspects of the structure and dynamics of the Earth's interior. The links between heat, pressure, mineral properties and density variations are explored for the mantle in terms of seismology, mineral physics and geodynamics, in order to understand how planetary differentiation and plate tectonic processes have shaped the Earth's interior structure.

Subduction zone geology, kinematics and geometry are discussed and linked to mantle dynamics. Mountain building processes and their consequences (driving forces, rheology, brittle deformation, metamorphism, basin formation) are discussed by studying different segments of orogens. Emphasis is placed on linking processes in the Earth's interior to surface expressions. The course consists of lectures, practicals and presentations, and is concluded with an exam.

Energy Transition

6 EC · constrained choice in Earth System Dynamics · elective in Global Environmental Change & Policy

This more applied course explores the geological aspects of the global shift from fossil fuels to sustainable energy systems. Students learn about energy resources, renewable energy technologies, geothermal energy, storage of CO_2, hydrogen and heat, and the exploration of (critical) raw materials within their geological context.

The course emphasises the interactions between the Earth system, energy production and resource management in order to assess pathways towards a more sustainable, low-carbon and resilient energy future. It includes lectures from partners in industry, and consists of lectures, computer practicals, group assignments and an exam.

Magmatic and Ore Forming Processes

6 EC · constrained choice in Earth System Dynamics

This advanced course focuses on the chemical aspects of magma generation in the mantle and magma evolution in the crust, and on their role in the formation of mineral deposits. It provides an overview of the geochemical structure and the evolution of the Earth's interior in terms of major and trace elements and isotopes. Processes of magmatism and magma evolution are discussed for various tectonic and geodynamic settings.

Through case studies based on geochemical datasets, students develop an integrated understanding of how physical and chemical processes control magma compositions and ore formation. The course is based on lectures, including invited external speakers, literature study and discussion, and an exam.

Learning path: Skills and methods

Graduates of the MSc Earth Sciences are highly appreciated on the job market for their mastery of Earth science skills. Beyond the plain application of laboratory or data analysis tools, feedback from the sector highlights their ability to apply these skills independently in order to analyse and further understand Earth system dynamics and to design solutions. The Earth System Dynamics specialisation therefore contains an extensive learning path on skills and methods, covering spatial data analysis, GeoAI, laboratory skills, fieldwork skills, Earth observation and proposal writing.

Advanced Spatial Analysis and GeoAI

6 EC · compulsory in Earth System Dynamics and in Global Environmental Change & Policy

In this course students acquire advanced skills to conduct spatiotemporal analysis in the context of Earth and environmental sciences, including geospatial AI methods in Python. The first part focuses on reading and writing spatial and time series data, libraries for handling spatial and time series data, data analysis, and visualisation of results. Students apply these tools in several practical cases, such as making climate stripes, simulating wildfires and optimising an energy grid using weather data.

In the second part, students learn about several geospatial AI tools, such as using machine learning to detect flood events in satellite imagery through image segmentation, and performing time series analysis on river discharge using LSTMs (a type of recurrent neural network). A further GeoAI case study focused on another Earth science topic is under development.

Isotopes in Earth Sciences

6 EC · compulsory in Earth System Dynamics

This course introduces students to the fundamental principles of isotope geochemistry and the application of isotopic systems to investigate Earth surface and planetary processes. It explores both stable and radiogenic isotopes and their use in biogeosciences, climate science, geomorphology, geochronology, planetary geochemistry, archaeology and forensic science.

Students learn how isotopic tracers are applied to study the carbon cycle, reconstruct past climates, and quantify geological processes using low-, medium- and high-temperature thermochronometers. Emphasis is placed on understanding the evolution of the Earth system across a range of temporal and spatial scales. The course provides essential foundational knowledge for the advanced thematic courses in the second year of the programme.

Lab Practicals

6 EC · compulsory in Earth System Dynamics

This course offers students hands-on experience in the various state-of-the-art laboratory facilities of Earth Sciences at VU Amsterdam. The aim is to familiarise students with analytical protocols and with data acquisition and evaluation, using various types of samples, equipment and datasets.

Through a combination of lectures and practical sessions, the course explores the potential causes of climate change and environmental impacts during the Late Glacial period in Western Europe and beyond, with particular emphasis on the Younger Dryas event, including the Laacher See volcanic eruption. The lectures provide essential background on the methodologies used and demonstrate how information from different disciplines can be integrated. The practical sessions are designed to generate new data on the sedimentological, botanical, geochemical and isotopic characteristics of sedimentary and volcanic deposits, and to interpret the findings with the aid of existing literature. Examination is based on the execution of laboratory assignments, data interpretation, and presentation of the results.

Fieldwork Geology

6 EC · constrained choice in Earth System Dynamics (alternative: Fieldwork Hazards and Risk)

This fieldwork gives students the opportunity to explore a cross-disciplinary approach to understanding the Earth's physical processes on the basis of field observations. The aim is to determine the strong interrelations between magmatic, tectonic, sedimentary, surface and climate processes through fieldwork.

The knowledge and theory gained during the fieldwork lead to a broadening of general geological, geomorphological and climatological insight into the different physical processes that affect the Earth at different timescales. The fieldwork is organised in the form of independent projects that students tackle in groups of two to three.

Advanced Earth Observation

6 EC · constrained choice in Earth System Dynamics · elective in Global Environmental Change & Policy

In this course students gain an in-depth understanding of the theory behind Earth observation data and experience in using it. This includes, among others, remote sensing data and reflection seismic data.

Advanced Earth System Modelling

6 EC · compulsory in Earth System Dynamics

In this course students obtain in-depth knowledge of numerical modelling through a series of lectures and hands-on modelling practicals. Examples come from climate models, geodynamic models and Earth surface models.

The focus is on the underlying physical mechanisms, the importance of timescales and scaling theory; on gaining a good understanding of how to optimally design numerical model experiments in order to answer a specific research question; and on the combination of these model results with various sorts of geological data.

Research Proposal A and GeoSolutions / Research Proposal B

2 × 6 EC · compulsory in Earth System Dynamics and in Global Environmental Change & Policy

The current Research Proposal course is split into two courses that follow the VU 8-8-4-8-8-4 structure and that more clearly separate the two aims of the course. In part A, students work on state-of-the-art problems that are currently being addressed by problem owners such as scientists and society or industry partners. In part B, students gain hands-on experience in designing an interdisciplinary research proposal.

Throughout the course, students learn to develop creative and innovative interdisciplinary research ideas; translate cutting-edge research ideas into research plans; synthesise and communicate ideas orally and in writing; and work in interdisciplinary teams.

In part A, students first learn the theory behind formulating a research question, designing a research project and writing a research proposal. The remainder of part A consists of one-day workshops offered by various problem owners, such as colleagues from the departments Earth Sciences (AAW) and the Institute for Environmental Studies (IVM), and governmental, societal and industry partners, in which the theory can be put into practice. These workshops consist of a theoretical and a hands-on part and are assessed in written or oral form.

In part B, students work in an interdisciplinary team to design, write and submit a research proposal for a problem put forward by a problem owner from science or industry. If the intended thesis research of a student requires additional field or laboratory work, or other highly specialised work, this can be done instead of part B.

Courses from the current programme

A number of courses in the draft curriculum continue unchanged or with minor changes from the current programme. This holds for example for the compulsory courses of the Global Environmental Change & Policy specialization: Global Change, Geopolitics and Conflicts; Environmental Economics for GEC&P; Economics of Environmental Policy; Land Use Change and Ecosystems; Earth Science Observation Research Methods; Environmental Policy for GEC&P; Climate Impacts and Policy; and Fieldwork Hazards and Risk – and for the electives offered from the MSc Hydrology, the MSc Environment and Resource Management and the science communication learning path. Descriptions of these courses are available in the VU study guide: studiegids.vu.nl. Please note that course titles and content in the study guide refer to the current academic year and may differ from the draft curriculum described here.