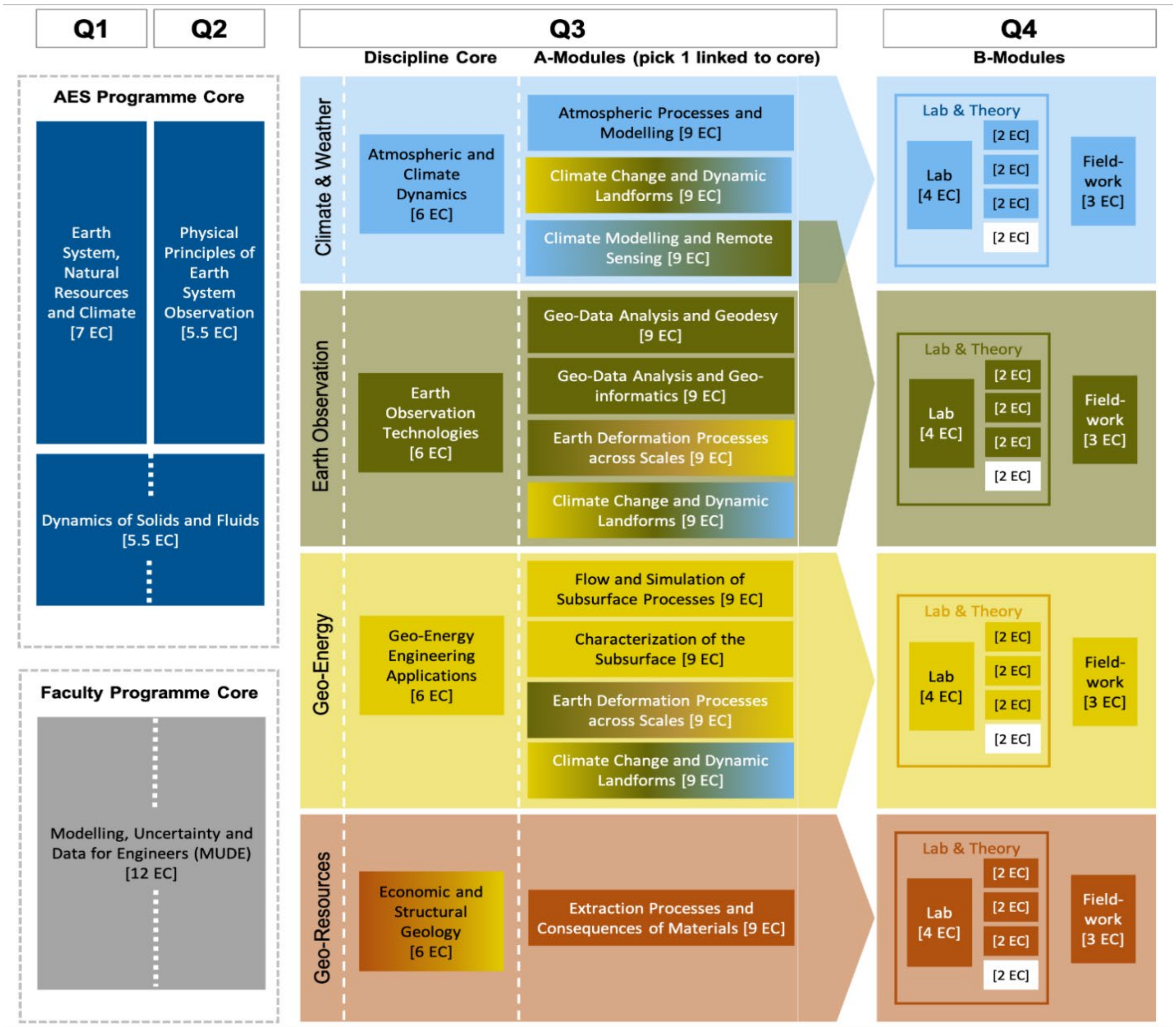
MSC APPLIED EARTH SCIENCES YEAR 1: DISCIPLINE GEO-ENERGY

The programme starts with a common core where you gain a solid foundation in earth science, physics, and modelling & data skills. Thereafter you develop your own path, and specialise in specific topics:

- you select one of four defined disciplines: Climate & Weather, Earth Observation, Geo-Energy, and Geo-Resources.
- you choose a mix of modules and electives, developing in-depth knowledge within the discipline or complementing your interests with electives from other disciplines.
- You gain hands on experience by applying theory learned to current engineering case studies from governmental institutes and companies.

This document presents an overview of the curriculum and module descriptions specifically for Discipline Geo-Energy in year 1 of the programme.



GEO-ENERGY: DISCIPLINE CORE AND A-MODULES

Geo-Energy Engineering Applications [6 EC]

Flow and Simulation of Subsurface Processes [9 EC]

Characterization of the Subsurface [9 EC]

Earth Deformation Processes across Scales [9 EC]

Climate Change and Dynamic Landforms [9 EC]

GEO-ENERGY ENGINEERING APPLICATIONS (DISCIPLINE CORE)

In this discipline core module, you will gain a comprehensive understanding of geothermal energy, petroleum exploration and production, and subsurface energy storage. You'll explore how these application areas contribute to the world's energy demand, how they can help in the transition towards a carbon-neutral world, as well as the boundary conditions and consequences associated with them.

Throughout the module you'll gain an understanding of reservoir characterization and single-phase flow and the effects of subsurface engineering. You'll learn about energy transition towards a CO_2 neutral energy production, including the role of the subsurface in this transition.

In parallel to this discipline core module, you follow one of four A-modules which allow you to either deepen or complement your focus on Geo-Energy.

FLOW AND SIMULATION OF SUBSURFACE PROCESSES (A-MODULE)

AESM304A
Flow and Simulation of Subsurface Processes

- Modelling geological heterogeneities
- Multiphase Flow in Porous Rock
- Num. methods in Subsurface Geoscience Simulations

In this module, you will gain the skills and knowledge needed to accurately model subsurface reservoirs and the fluid/energy flow passing through them.

Divided into three units, you will learn how to analyse sedimentary and structural models to understand the distribution of effective rock properties, facies, faults, and fractures in subsurface reservoirs.

You will also learn how to use both analytical and numerical methods to describe and model fluid and energy flows through these reservoirs, both for single-phase and two-phase fluids.

Throughout the module, you will develop your own models, analyse the outcomes, and reflect on the uncertainties and variations inherent in sedimentary and structural heterogeneities.

The module will also emphasize the importance of scale in understanding and solving key issues related to geo-energy engineering applications, including geothermal energy, subsurface storage, hydrocarbon production, and the consequences of subsurface engineering.

CHARACTERIZATION OF THE SUBSURFACE (A-MODULE)

AESM305A
Characterization of the Subsurface

- Modelling geological heterogeneities
- Geomechanics and Structural Geology
- Surface Morphodynamics and sedimentation

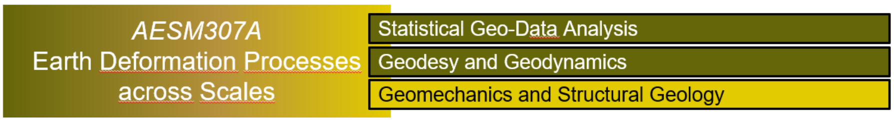
In this module you will focus on the structural and sedimentological architecture of the rocks in the Earth that are important for Geo-Energy Engineering applications. You will assess and quantify the properties of rocks and their variabilities on all scales, and learn about the different processes that occur in and at the Earth's surface. This knowledge will help you assess and predict subsurface architecture and properties.

This module will cover a range of topics including how subsurface reservoirs are built up with respect to reservoir properties and facies distributions, and how changes in these properties and distributions can be correlated to variations in sedimentary deposition due to past climate fluctuations within different tectonic settings. You will also learn about the structural framework in the subsurface, including tectonics, deformation, compaction, faulting, and folding.

Throughout the module, attention will be given to heterogeneity, variations, and the issue of scale in subsurface characterization. You will learn how process-based understanding of sedimentary and tectonic processes is used to accurately populate subsurface reservoir models and how to predict variations in these properties both in space and time.

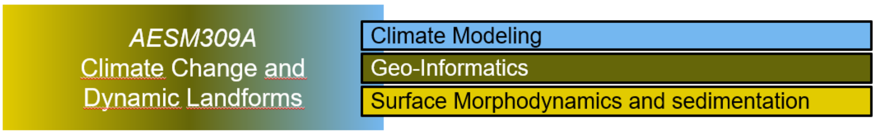
By the end of the module, you will have a thorough understanding of how the rocks in the Earth are structured and how they can be used for Geo-Energy Engineering applications.

EARTH DEFORMATION PROCESSES ACROSS SCALES (A-MODULE)



This module will equip you with the necessary knowledge and skills to comprehend, forecast, and describe Earth deformation processes. You will cover topics ranging from continental scale phenomena, like glacial isostatic adjustments and tectonics, to reservoir scales, such as folding, faulting, and compaction. You will be trained in geodetic and geophysical observation techniques to measure these deformation processes, estimate physical parameters, and evaluate their uncertainties. Additionally, you will learn how to correlate observed movements with subsurface engineering (e.g., resource extraction, storage, tunnelling) or natural processes (e.g., plate tectonics, Earthquakes).

CLIMATE CHANGE AND DYNAMIC LANDFORMS (A-MODULE)



This module is designed for students interested in studying how climate change affects the natural environment and how this can be analysed using geospatial data. The module is shared between the disciplines Climate&Weather, Earth Observation and Geo-Energy.

The module is split into 3 different units (Climate Modeling, Geo-Informatics, and Surface Morphodynamics and Sedimentation) where you will cover topics such as climate modelling and underlying concepts of numerical and computational models that predict past and future climate dynamics. You will also learn about the interaction between climate change and the solid Earth, using rivers and deltas as natural case studies. Additionally, the module includes a hands-on component where you'll learn how to deliver remote sensing products that can be used in geophysical studies. By the end of the module, you'll have a better understanding of how the natural environment is impacted by climate change and how to use modeling and observations to study these impacts over time.

GEO-ENERGY: B-MODULES

The B-modules for all disciplines comprises a Theory & Lab component (12 EC) and a fieldwork (3 EC).

The lab has a central place in the module, triggering the inquiries and as the place where the students apply the theory they learn in the theory units to a challenge related to monitoring and/or prediction of climate impacts or geohazards, energy transition, or responsible resource extraction (depending on the discipline). The student (team) selects a topic related to the challenge within a predefined theme that they will work on during the Lab. They collect analyse and interpret data to address or solve their posed topic.

Next to the lab project, students follow 4 theory units. One is compulsory per discipline (indicated with ‘C’ in table below). In addition, students need to choose 2 units from their own discipline. The available options are indicated in the table below per discipline.

Discipline	Theory components (colour indicates with discipline offers it)	B-CW	B-EO	B-GE	B-GR
C&W	Climate data analysis	C	E	E	
	Remote sensing of precipitation	E	E		
	Multi-sensor cloud and atmospheric observations	E	E		
	Cryosphere dynamics	E	E		
	Sea level change and extremes	E	E	E	
EO	Time series analysis	E	C	E	
	GNSS	E	E		
	(In)SAR	E	E	E	
	Optical remote sensing	E	E	E	E
GE	Induced seismicity		E	C	
	Geophysical prospecting		E	E	E
	Production science and technology	E		E	
	Geological interpretation of geophysical data		E	E	
GR	Exploration tools and methods			E	C
	Advanced resource modelling			E	C
GR + EO	Geostatistical data analysis		E	E	C

C	compulsory
E	elective

During the fieldwork, students will work in teams to define an objective related to their discipline. Students start with a project planning phase (0.5EC), in which they receive instruction, and they design a measurement experiment or a fieldwork campaign, which will be reviewed. In a second phase they will implement the measurements, collect data and process the data (1.5EC). Thereafter they will analyse and interpret the data, present their findings, and provide recommendations for future work or answer questions in different formats (1EC).

Geological interpretation of geophysical data
• Explain what information is present in geophysical data (images and attributes) and to what extent the data can be reliably used for their geological interpretation and apply this to the geophysical data sets. • Provide a geological interpretation of the structure, the sedimentary environment, and the properties of the rocks imaged in a geophysical data set related to Energy Transition and Geohazard applications.
Geophysical prospecting
• Formulate the basic connections between the physical properties of matter and the wave, diffusive and potential field measurements. • Choose and apply the proper method(s) to solve a specific problem related to Energy Transition or Geohazard applications.
Production science and technology
• Explain the differences between production technology in hydrocarbon, geothermal and subsurface-storage industry, and evaluate risks and safety issues of its well drilling and operations. • Evaluate production facilities in terms of production scenarios, well productivity, artificial lift, formation damage, well stimulation (acidizing and fracturing), and well performance.
Induced seismicity
• Describe and explain the mechanisms of, and the effects that engineering applications in the subsurface have on the natural and build environment and society, for example induced seismicity, subsidence, and cap rock integrity. • Integrate knowledge of ethical issues, international standards and risk management systems into Energy Transition and Geohazards applications.