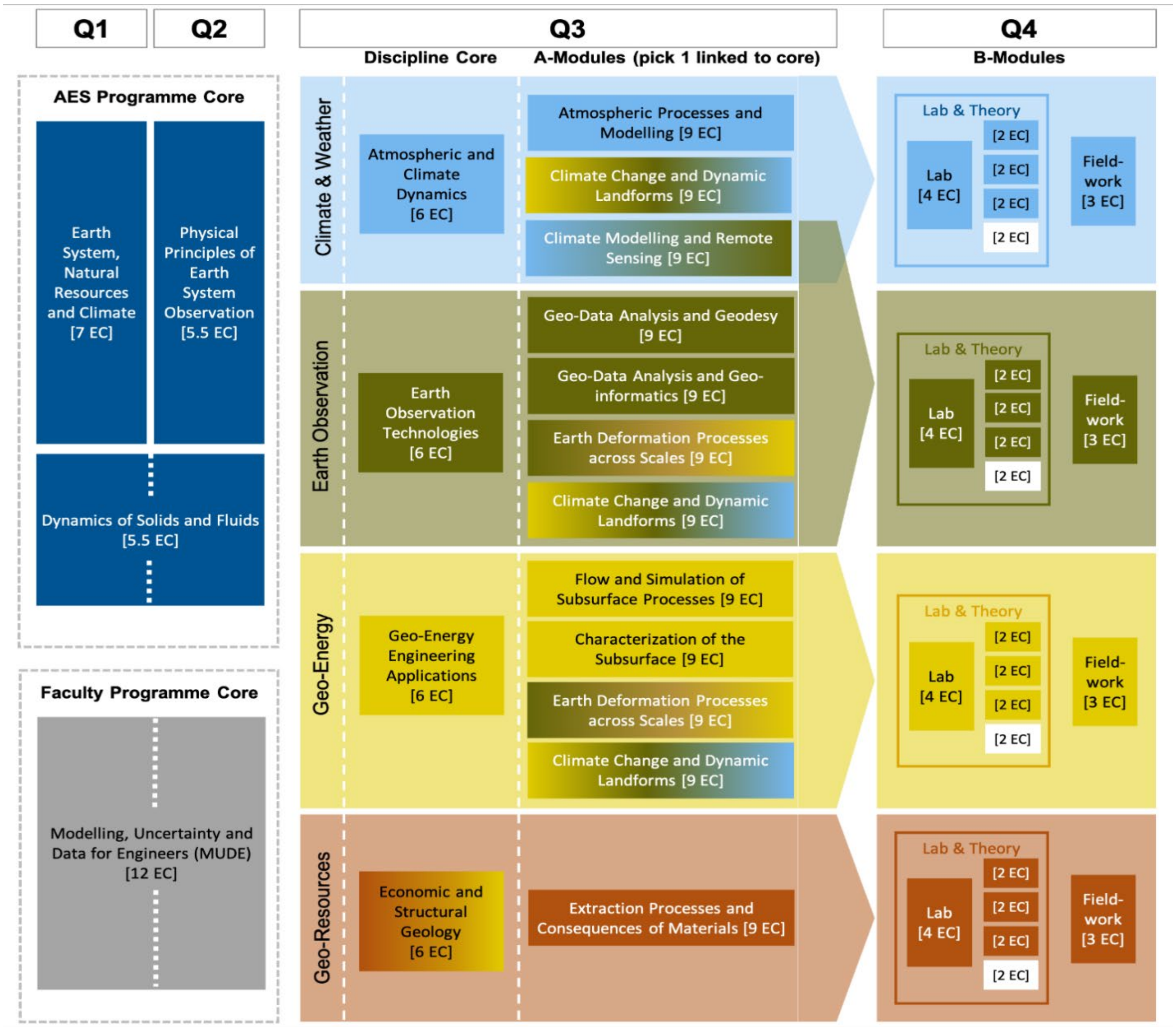
MSC APPLIED EARTH SCIENCES YEAR 1: EARTH OBSERVATION MODULE DESCRIPTIONS

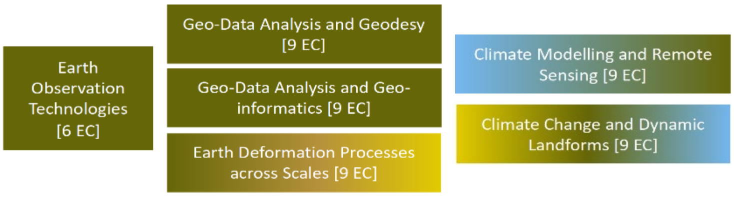
The programme starts with a common core where you gain a solid foundation in earth science, physics, and modelling & data skills. Thereafter you develop your own path, and specialise in specific topics:

- 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.

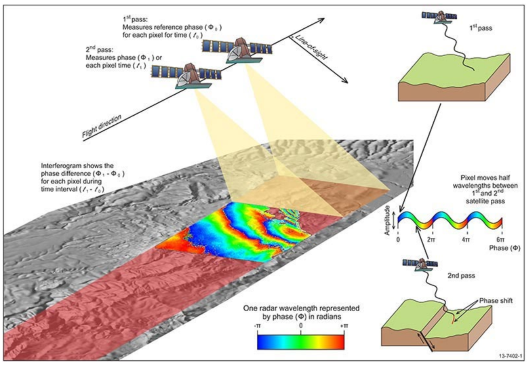
This document presents an overview of the curriculum and module descriptions specifically for Discipline Earth Observation in year 1 of the programme.



EARTH OBSERVATION: DISCIPLINE CORE AND A-MODULES



EARTH OBSERVATION TECHNOLOGIES (DISCIPLINE CORE)



In this discipline core module you'll work with 4-6 fellow students on a mission/campaign (e.g. new satellite mission or a ground measurement campaign) motivated by topical scientific or societal issues. A domain expert will guide your exploration of available and emerging Earth Observation (EO) technologies.

You'll draw on your prior knowledge of underlying physical principles to select a suitable observation technique and you'll develop a preliminary high-level design that reconciles user requirements with the capabilities of the selected techniques. Together with your classmates, you'll learn how to interpret and analyse user needs and translate them into observational requirements. You'll perform quality assessments, estimate the parameters of interest, and reflect on the ability of the mission/campaign to meet the user requirements.

Parallel to this discipline core module, you follow one of five A modules, allowing you to go deeper in the field of Earth Observation, and possibly to complement it by gaining competencies from Climate & Weather or Geo-Energy disciplines.

GEO-DATA ANALYSIS AND GEODESY (A-MODULE)

AESM302A Geo-Data Analysis and Geodesy	
	Statistical Geo-Data Analysis
	Fourier Analysis in Earth Sciences
	Geodesy and Geodynamics

This module is designed for students who are interested in using geo-data to track changes in the shape of the Earth's surface and its gravity field. The signals of interests can be related to local human activities, such as gas or ground-water extraction, or, for example, related to climate change, such as ice-mass losses in Greenland or Antarctica. You'll gain skills and theoretical knowledge to help you process Earth observation data: you'll be able to handle errors in the data, assess the quality of input data, and estimate parameters in the presence of noise. Furthermore, you'll be able to identify signals of interest using Fourier analysis methods.

Additionally, you'll learn how to link the estimated parameters and signals to underlying geodynamical processes, such as Earth tides, glacial isostatic adjustment, and tectonic processes, including earthquakes. By the end of the module, you'll have a deep understanding of the key geophysical processes that influence changes in the Earth's surface and be able to apply your knowledge to real-world scenarios

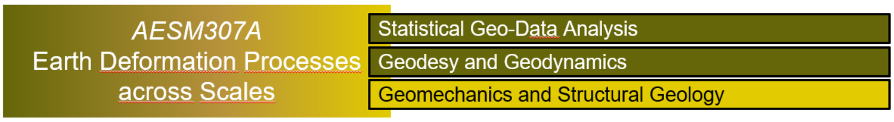
GEO-DATA ANALYSIS AND GEO-INFORMATICS (A-MODULE)

AESM303A Geo-Data Analysis and Geo-informatics	
	Statistical Geo-Data Analysis
	Fourier Analysis in Earth Sciences
	Geo-Informatics

In this module you will delve into geospatial data mining and communication. You'll explore state-of-the-art techniques for visualizing and processing geospatial data, using geographic information systems and various formats and map projections.

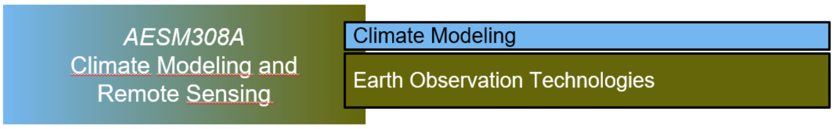
You'll also learn how to assess the quality of input Earth observation data and how this impacts the final product's quality. By analysing various methodologies, you will assess the spatial-temporal content of data, including identifying repetitive patterns and scales of information. This will give you the tools to extract meaningful information from the data and communicate it effectively to different stakeholders.

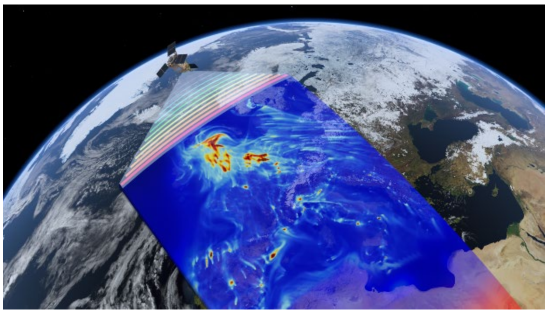
EARTH DEFORMATION PROCESSES ACROSS SCALES (A-MODULE) – SHARED WITH GEO-ENERGY



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 MODELLING & REMOTE SENSING (A-MODULE)- SHARED WITH CLIMATE & WEATHER

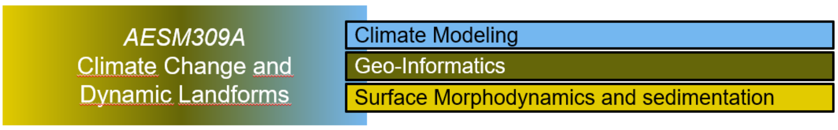




This module is shared across the Climate & Weather and Earth Observation disciplines. This is reflected in the module's two units: Climate modelling and Earth Observation Technologies. By following this module, you will learn how remote sensing and climate modelling have a certain type of synergy which helps you understand, predict, and model a wide range of present-day climate system processes. This enables you to study and analyse processes related to the cryosphere, terrestrial water cycle, oceans, and/or the interactions between these components. You will not only gain a physical understanding of the processes, but also the skills needed to use and assess ground-based and space-borne observations, and coupled global models. As part of the module, you will create a preliminary design for an observation mission/campaign, giving you valuable hands-on experience and a deeper understanding of tradeoffs/compromises you will have to make when working in the field with certain techniques.

or more information about this A-Module click here.

CLIMATE CHANGE AND DYNAMIC LANDFORMS (A-MODULE)- SHARED BETWEEN EARTH OBSERVATION, CLIMATE & WEATHER, AND GEO-ENERGY



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.

EARTH OBSREVATION: 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).

Time series analysis

Exploring the temporal structure of Earth observation data is one of the key skills of every engineer and scientist. In this component we will familiarize students with the analysis of time series using parametric techniques. They can be applied to both stationary and non-stationary data records, can deal with data gaps and unevenly space data, and abrupt changes in the time series. Moreover, students will learn to deal with different data noise models, assess the uncertainty and significance of estimated model parameters, and decide between competing models. In the Lab students will familiarize themselves with the implementation and application of the techniques for various types of data.

GNSS

Global Navigation Satellite Systems (GNSS), such as GPS, have revolutionized positioning and navigation, and resulted in novel geoscience applications. Topics:

- Fundamental principles of Global Navigation Satellite Systems (GNSS): signals, observables, noise characteristics, error sources;
- Methods to improve the accuracy of standard GPS positioning down to the millimeter level. You will discover the techniques that make millimetre GNSS possible: interferometric measurement principle, differential/relative positioning with two (or more) receivers, carrier phase measurement, mathematical models with single- and double-differences, carrier phase ambiguity resolution.
- High-precision positioning algorithms and implementation aspects for applications in monitoring and prediction of geohazards and climate impacts.

Optical remote sensing

Topics: Recap of fundamental principles of optical sensors (e.g., multi/hyperspectral, trade-off spatial/temporal/spectral resolution) and signals (e.g., EM interaction with atmosphere/land, noise). Data processing chain to derive/extract geophysical parameters (+uncertainty) from optical remote sensing data:

- Error correction and pre-processing (atmospheric/geometric/radiometric correction)
- Image enhancement methodologies (e.g., band transformations)
- Image regression / classification using: Spectral information, Spatial information, Contextual information, Segmentation (object-based information), Sub-pixel information

(In)SAR

Synthetic Aperture Radar (SAR) systems provide high-resolution images of the Earth Surface independently of illumination conditions (i.e. day or night, or also during polar winters) and of weather conditions.

Aside from being sensitivity to properties of the surface (for example, the backscattered intensity is modulated by soil moisture variations), complex-valued SAR data carry information about the distance between the radar and the object. SAR interferometry (InSAR) exploits this to, for example, observe deformation of the surface, being able to detect deformations rates in the order of millimeter per year. With the guaranteed availability of long-term dense time series of global observations provided by, for example, the Copernicus Sentinel-1 mission, and the emergence of satellite-data providers from the private sector, SAR and InSAR data will continue to consolidate as one of the main sources of reliable information to monitor process related to natural hazards, climate change, or a diversity of human related activities. Topics:

- Understanding SAR data: observation geometry and radar coordinates, resolution; speckle, radiometric quality, geometric and non-geometric contributions to the phase, etc.
- Foundations of InSAR: cross-track InSAR; differential InSAR; coherence and phase quality; atmospheric effects; systematic errors, InSAR processing, phase unwrapping.
- Persistent Scatterer Interferometry and InSAR time-series (stacks).