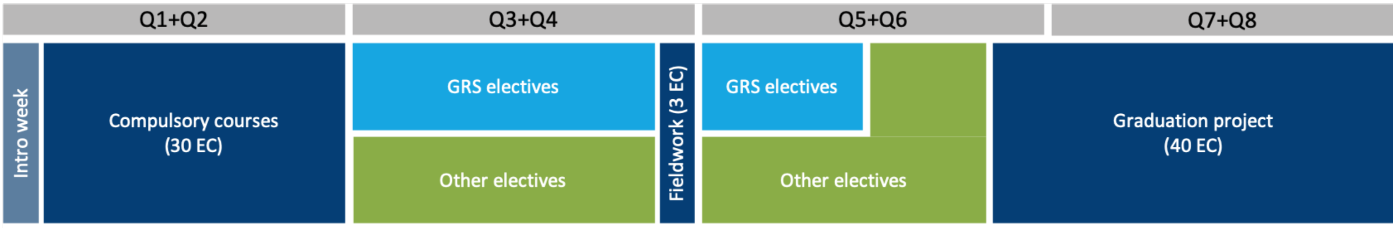
GEOSCIENCE AND REMOTE SENSING - PROGRAMME OVERVIEW



In the program we distinguish three categories, for each category you can find the details in the figure below:

Compulsory courses + graduation project (33+40EC)

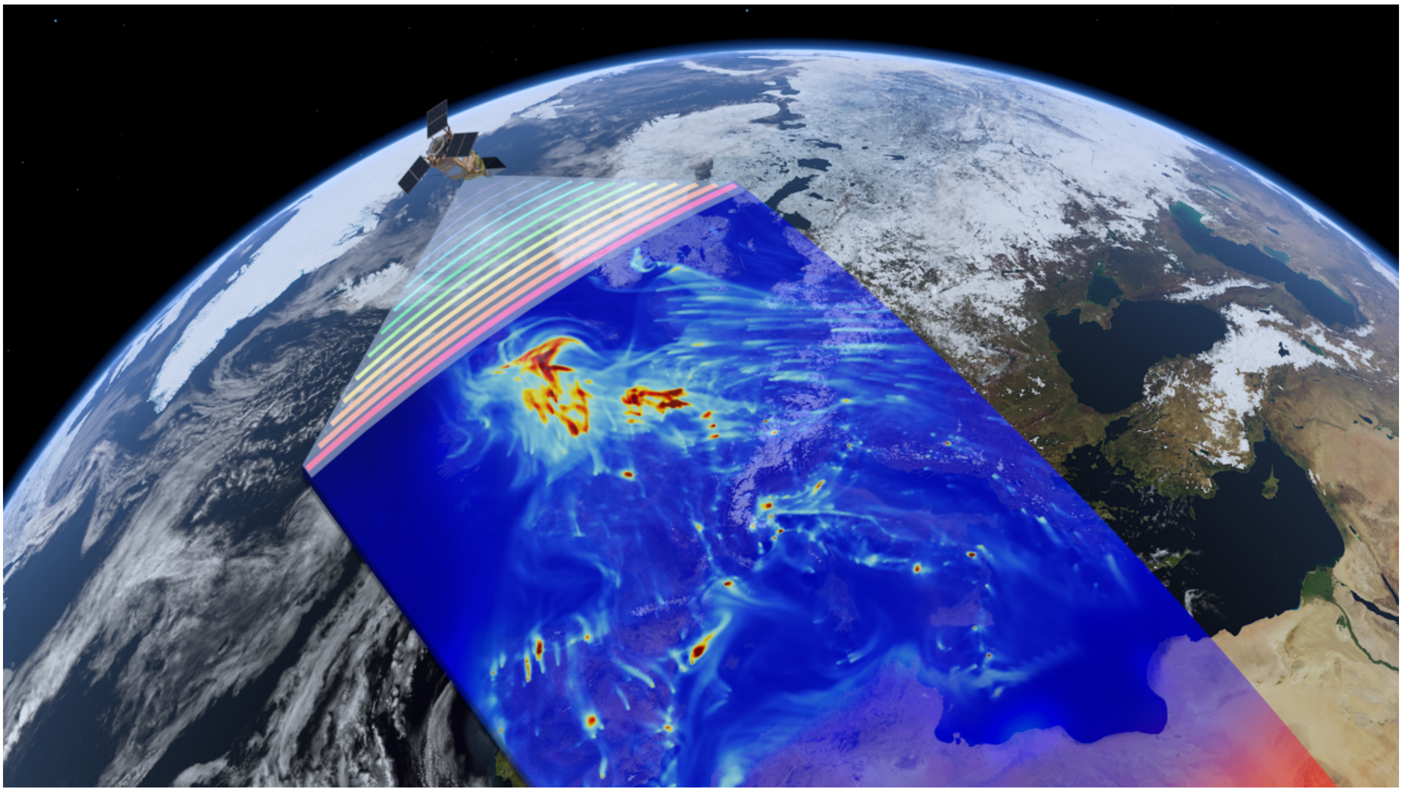
Quarter 1	EC
CIE4601 Physics of the Earth and Atmosphere	5
CIE4606 Geodesy and Remote Sensing	5
CIE4611 Geo-measurement Processing	5
Quarter 2	
CIE4603 Geo Signal Analysis	6
CIE4510 Climate Change: Science and Ethics	4
CIE4604 Simulation and Visualisation	5
Quarter 4 (week 4.9+4.10)	
CIE4615 GRS Fieldwork	3
Quarter 7+8	
Graduation project	40

GRS electives (at least 20 EC)

Quarter 3	EC
CIE4602 Cryosphere: Remote Sensing and Modeling	4
CIE4605 Atmospheric Turbulence	4
CIE4607 Ocean Topography and Sea Level Change	4
CIE4614 3D Surveying of Civil and Offshore Infrastructure	5
CIE4620 Climate Data Analysis	5
CIE5401 GIS and Remote Sensing	3
Quarter 4	
CIE4608 Atmospheric Remote Sensing	4
CIE4609 Geodesy and Natural Hazards	4
CIE4610 Gravity, Geodynamics and Climate Change	4
CIE4522 GPS for Civil Engineering and Geosciences	4
CIE4708 Water in the Atmosphere	5
Quarter 5	
CIE4616 Remote Sensing and Big Data	5
CIE4625 Climate Modeling	5

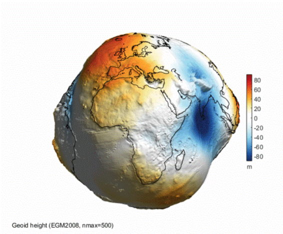
Other electives (27 EC)

	EC
Track-related courses, choose from: • GRS electives (see blue box) • Internship, Additional Thesis or Multidisciplinary Project • Courses from other Master programmes with a link to GRS (to be approved)	17
Free electives	10



COMPULSORY COURSES

GEODESY AND REMOTE SENSING (5EC)

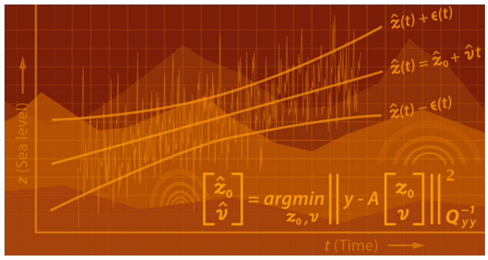


In this course you will first learn about the discipline of Geodesy and its role in Earth sciences. Geodesy is a fundamental geoscience, using earth observation technologies (from satellites, airplanes, vehicles and terrestrial platforms) to get information about our System Earth in terms of geometry/shape, dynamics and gravity field. Geodesy also provides the foundation to represent horizontal and vertical positions in global and national reference frames, which is essential to support societal needs for geospatial data.

The second part of this course is on principles and applications of remote sensing, which basically means to 'observe from a distance'. Different remote sensing techniques will be discussed and you will learn how to select the appropriate sensor platform for the application at hand.

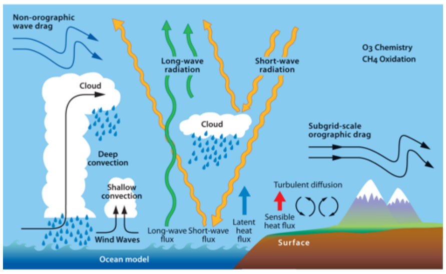
GEO-MEASUREMENT PROCESSING (5EC)

Measurements are key to Geoscience and Remote Sensing. The focus of this course is on the mathematical and statistical aspects in the process of going from measurements to results, interpretation, decisions and conclusions.



The course introduces a standardized approach for parameter estimation, using a functional model (relating the observations to the unknown parameters) and a stochastic model (describing the quality of the observations). Using the concepts of least squares and best linear unbiased estimation (BLUE), parameters are estimated and analyzed in terms of precision, significance and validity. Emphasis is given to develop hands-on experience, i.e. to work with actual measurement data (GNSS, gravity, radar, lidar, etc).

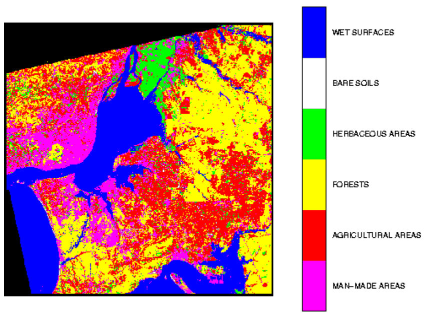
PHYSICS OF THE EARTH AND ATMOSPHERE (5EC)



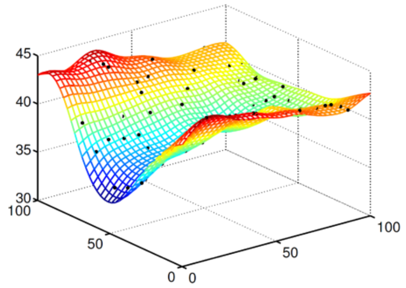
This course will present a common introduction to the major Earth system components, including the atmosphere, ocean and solid earth. Basic physical principles will be discussed and numerous examples from observations will be shown to provide the students with an elementary background in some key phenomena that occur on Earth.

SIMULATION AND VISUALISATION (5EC)

Simulation and visualization of remote sensing applications requires a diverse range of skills which involve not only programming, but also knowledge such as how to break down the problem into logical elements, how to manage the data sets involved, or how to visualize results for presentations and interpretation. Through a series of hands-on interactive training sessions, students in this course will have the opportunity to develop these skills by working through a collection of scientific and engineering tasks, and problems, typical for the remote sensing applications, that they are to encounter in their future academic/industrial careers.



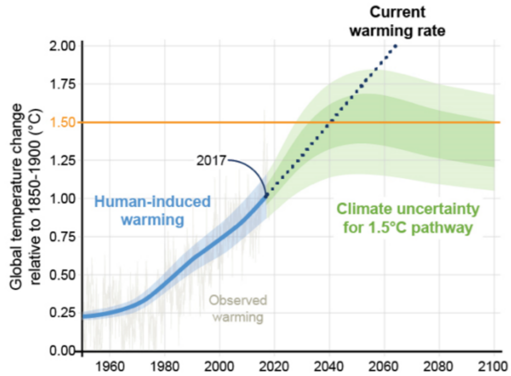
GEO-SIGNAL ANALYSIS (6EC)



This course introduces the basic concepts, tools and techniques for analyzing data in geosciences and remote sensing: deterministic interpolation, structural analysis, kriging, classification, Fourier transform, spectral analysis, filtering and smoothing. The goal is to gain a good theoretical and conceptual understanding of these techniques by applying them to real-world problems and datasets derived from ground-based, airborne and space-borne sensors. After this course the student should be able to assess the structure and information content of spatially and temporally distributed data.

CLIMATE CHANGE AND ETHICS (4EC)

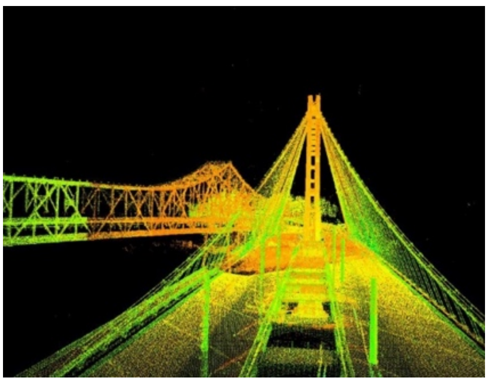
The course provides an introduction to the basic physics of the climate system, how climate has changed in the past and how climate will change in the future. The focus in on the energy balance of the climate system and how this balance is affected by greenhouse gases and aerosols; the physical processes in the atmosphere and oceans that shape the climate; the response of the oceans, ice sheets and glaciers to global warming; the evidence for past and present climate change; climate models and model uncertainties; climate predictions.



A second focal point of the course is the broader societal and ethical aspects of climate change. In particular, we will focus on past emissions and responsibilities, implications of global warming on human safety and security, the distribution of burdens and benefits, emission rights, international justice and intergenerational justice.

GEOSCIENCE AND REMOTE SENSING ELECTIVES (CHOOSE AT LEAST 20 EC)

3D SURVEYING OF CIVIL AND OFFSHORE STRUCTURES (5EC)

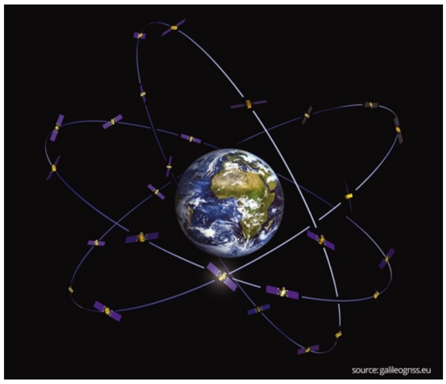


Surveying is of key importance for any construction or infrastructural project – in the planning and preparation phase and the construction phase itself, but also afterwards during the actual operation. Applications to be considered are tunnelling, planning and construction of roads and railways, monitoring and maintaining dikes, construction and monitoring of buildings, bridges and dams. In this course you will learn how to solve a number of specific surveying problems: which techniques are available and can be used for specific applications in relation with the required accuracy?

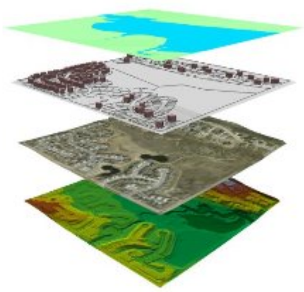
The larger part of the course concerns the acquisition and processing of point clouds: massive numbers of measurements in 3D space. Point clouds are acquired by cameras and laser ranging instruments. After completing a survey, 3D measurement and object reconstruction can be performed. Recognition of objects and extraction of other relevant information from point clouds are covered in the course, as well as representation of the results by means of Digital Terrain Models.

GPS FOR CIVIL ENGINEERING AND GEOSCIENCES (4EC)

Global Navigation Satellite Systems (GNSS), such as GPS, have revolutionized positioning and navigation, and resulted in novel applications. This first part covers the basic principles and components of GNSS. You will learn how a basic GNSS receiver computes the position and get a basic understanding of the error sources, accuracy and limitations of GNSS. Next, we will focus on high-precision positioning and navigation, in particular the methods to improve the accuracy of standard GPS positioning down to the millimeter level. In addition, we will discuss the required GNSS infrastructure and high-precision implementation aspects. Finally, we will explore the different professional GNSS applications in civil engineering and geosciences, ranging from surveying, atmospheric remote sensing, to studying Earth dynamics at different scales.



GIS AND REMOTE SENSING (3EC)

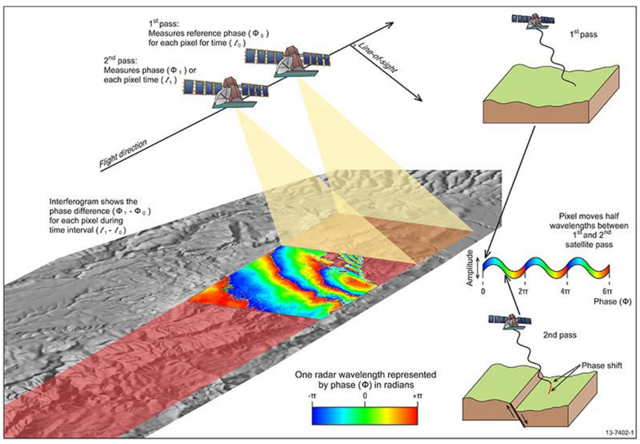


The course is designed to allow students to gain hands-on experience by applying Geographical Information Systems (GIS) and remote sensing data for different applications in water resources. In addition to the common GIS tasks of visualizing and analyzing data, we will use GIS tools to delineate watersheds, and to perform land classification and surface water identification and data analysis. The remote sensing component is focused around measurements in the visible, thermal and microwave regions of the spectrum. We will introduce the physics behind the measurements, and illustrate how observations in each region yield invaluable data for water resources. Remote sensing data will be used to analyze elevation and land cover distribution, as well as precipitation, soil moisture and evaporation patterns in a basin.

REMOTE SENSING AND BIG DATA (5EC)

Many image processing and analysis techniques have been developed to aid the interpretation of a range of images (e.g. satellite remote sensing, but also other types of raster datasets like climate data) and to extract as much information as possible from the image data. Recent advances in remote sensing and computer science has moreover resulted in an explosive growth of image data sets and data analysis techniques such as machine learning. This evolution is both a challenge and opportunity as it requires specific techniques to explore, analyse, and leverage the data. This course provides an overview of tools and techniques to explore, analyse, and visualise the image data and on the implementation of big data analytics techniques on these data to exploit the growing data archives.

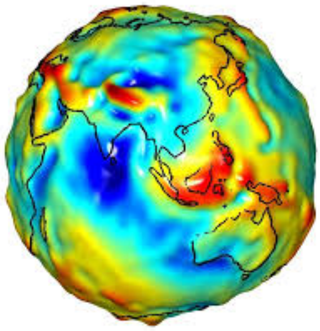
GEODESY AND NATURAL HAZARDS (4EC)



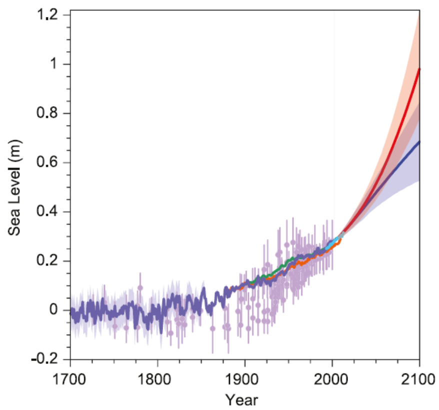
This course focuses on Synthetic Aperture Radar remote sensing, to monitor or forecast a range of natural hazards (volcanic eruptions, Earthquakes, tsunamis, landslides, land subsidence). The link between science and society, mitigation and risk reduction and how geophysical observations can improve our understanding of these phenomena will be discussed. The underlying geophysical processes of volcanoes, earthquakes and tsunamis, monitoring and modelling. The principles of radar remote sensing, including key performance indicators, such as resolution, sensitivity, spatial coverage and temporal sampling will be discussed. You will look at SAR image formation and post-processing and gain experience with interferometric processing steps and time series analysis.

GRAVITY, GEODYNAMICS AND CLIMATE CHANGE (4EC)

The course is devoted to the study of the Earth using its gravity field. Temporal variations of the Earth's gravity are the primary focus, since they reflect various mass transport processes associated with geodynamics and climate change. The first part is on general information about the Earth's gravity and its measurement. Next, the mathematical representation of the Earth's gravity field is discussed. Finally, the relationship between temporal gravity field variations and mass transport will be assessed. The course is set up to meet the growing public concern about the future of our environment, as well as about a shortage of natural resources, including water. Any strategy of protecting against those threats requires a profound understanding of them. Large-scale mass transport in the Earth's system is one of the related processes, and gravimetry is the primary technique to observe and quantify it.



OCEAN TOPOGRAPHY AND SEA LEVEL CHANGE (4EC)



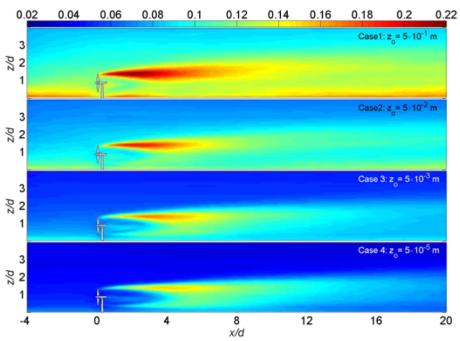
The ocean surface is continuously changing due to processes acting at different spatial and temporal scales. Sea level is affected by sub-daily tides, by multi-yearly changes in ocean circulation (e.g., El Nino), but also by climate change and by long-term geophysical processes. For instance, global mean sea level is currently rising at a rate of about 3 mm/yr and is expected to accelerate during the coming decades. Monitoring and understanding sea level changes requires a combination of different techniques. The course is about the observation techniques – satellite radar altimetry and tide gauges – used to measure sea level variations including their potential and limitations, the analysis of the data provided by the measurement sensors, and their application to the study of the geophysical processes causing sea level variations.

CRYOSPHERE: REMOTE SENSING AND MODELING (4EC)

This is a course on the physics of the parts of the Earth System that contain frozen water (the seasonal snow cover, sea-ice, glaciers, and the Greenland and Antarctic ice sheets), on their interaction with the physical climate system, and on the techniques to observe these parts of the Earth remotely. Special emphasis will be given to glaciers and the Greenland and Antarctic ice sheets, that are currently losing mass at an accelerated pace and becoming a major contributor to sea level rise.

Topics are The Cryosphere and Climate Change, Snow and ice surface processes (accumulation, melt, refreezing, sublimation), Glacier flow, Ice sheet and Climate coupling.

ATMOSPHERIC TURBULENCE (4EC)



This course focuses on various fundamental and applied concepts related to meteorology with an emphasis on the lower part of our atmosphere. The following specific topics will be covered during the quarter: structure of turbulence and similarity theories; boundary layer modeling and parameterization schemes; land-surface interactions; radiation parameterizations; regional-scale numerical weather prediction; forecast verification; predictability and ensemble forecasting. In addition, real-life problems from the fields of wind energy, solar energy, atmospheric optics, and air quality will be discussed throughout the course.

ATMOSPHERIC REMOTE SENSING (4EC)

In the first part of this course you will learn about the relation between atmospheric observation and observation scales of the atmosphere, as well as the sensors that can be used. The second part is on the observation of the dry atmospheric composition (gasses and aerosols). We will discuss scientific questions and challenges concerning the ozone layer, air quality and the climate system, short description of chemical composition of the atmosphere. Furthermore, we will look at the physical principles of the solar backscatter observation techniques (UV and visible), and both ground-based and satellite-based observation techniques. In the third part, the observation of the wet atmospheric composition (condensed water) is discussed using ground-based radars with a focus on precipitation.

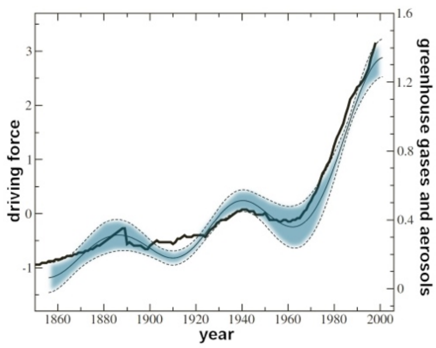
WATER IN THE ATMOSPHERE (5EC)

This course deals with atmospheric processes on all relevant scales and relevant to water: the global scale (weather systems), intermediate scale (deep convection, turbulence), to the smallest scales of cloud droplets and aerosols. After reviewing fundamental concepts of radiative transfer and atmospheric thermodynamics, concepts from dynamic meteorology (cyclones, frontal systems) will be addressed. Moving to smaller scales, the theory of turbulent atmospheric boundary layers will be treated, distinguishing between convective, neutral and stable boundary layers (i.e. day-time and night-time situations). This paves the way towards addressing cloud formation processes, i.e. cloud dynamics and cloud-microphysics, and rain formation. Apart from treating the underlying principles and concepts, also attention will be devoted to observation, modelling and forecasting of the phenomena.

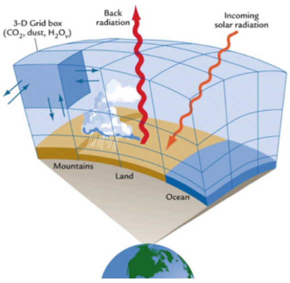
CLIMATE DATA ANALYSIS (5EC)

Analysis and interpretation of climate data - either field measurements, model or remote sense data - is largely based on statistical approaches. Students who pursue research in climate related topics should therefore have a solid background in statistics and be aware of the available methods, how to apply them correctly, and their pitfalls.

This course discusses key statistical methods and procedures used to analyze climate data. Students will apply the methods and procedures to real and simulated data.

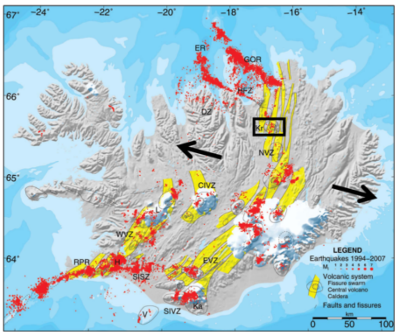


CLIMATE MODELING (5EC)



Climate modeling with General Circulation Models (GCMs) is the primary tool for predicting future climate. However, these models use assumptions and approximations that need to be taken into account to apply model results (e.g., for climate change mitigation and adaptation) and to further improve these models. GCMs are very complex models, and often simple models can be used to interpret GCM results. In addition, model ensembles are very useful to quantify uncertainty and put individual model results into context.

GEOSCIENCE AND REMOTE SENSING FIELDWORK



The first year of the Master track concludes with a fieldwork project in Northern Iceland. Both natural geophysical processes as well as human-induced deformation are causing vertical and horizontal movements of the Earth's surface in this region. Moreover, there are mass displacements due to groundwater circulation and volcanic processes. The aim of this course is to synthesize the knowledge and skills obtained in the first year of the Geoscience and Remote Sensing master track.

It includes:

- hands-on practice in planning and making observations with different techniques (e.g. GNSS, leveling, total station, gravimeter, meteo stations).
- Data processing, analysis and interpretation.
- Background classes on the physical processes being measured.

The assignment is given to the students in the form of a project on which they have to work in a team of 8-12 members. Important learning objectives are therefore also to learn how to contribute to a project as a team player and to the overall project management, and how to effectively communicate with peers, assessors and clients.