GEM Study Guide

Erasmus Mundus Joint Master Degree in Geo-Information Science and Earth Observation for Environmental Modelling and Management (**GEM**)

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ITC University of Twente

University of Tartu

UCLouvain

Lund University

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What is in this study guide

This study guide provides an overview of the structure and courses of the Erasmus Mundus Joint Master Degree in Geo-Information Science and Earth Observation for Environmental Modelling and Management (**GEM**) Master's programme for the academic year starting in September 2026.

The guide introduces the four partner universities, the structure and tracks of the **GEM** programme, and the overall learning outcomes of the **GEM** programme.

It also provides practical information on key dates in the academic calendars of each partner university (where already known for 2026-2028), and the scheduled teaching hours.

Finally, each course is presented with a description, course learning outcomes, teaching, and learning approach, time allocations, and assessment methods.

Practical information for students on travel, visas, housing, facilities, associations, and key contacts is published on the GEM website in the section **GEM Student Handbook** (https://www.gem-msc.eu/Student-Experience/)

Specific dates and courses may change slightly, but the overall programme remains the same.






Introduction to the GEM programme

About the GEM programme

Tomorrow's world is being shaped by those who harness data and technology to drive sustainable change. The GEM programme equips future leaders with the skills to model, manage, and restore socio-environmental systems across the globe.

Recent advances in Earth Observation (EO), GeoAI, and cloud computing have revolutionised our ability to monitor and model environmental systems. Yet, turning data into decisions requires skilled professionals who understand both the technology and the societal context. GEM offers an innovative MSc programme that prepares students to tackle global challenges - from climate resilience to sustainable land use - using geospatial intelligence.

GEM stands for *Geo-information Science and Earth Observation for Environmental Modelling and Management*. It is a prestigious Erasmus Mundus Joint Master's programme delivered by a consortium of **four top-tier European universities**. The GEM Programme combines the strengths of ITC-University of Twente, Lund University, UCLouvain, and University of Tartu.

- ITC-University of Twente (**ITC**) - The Netherlands
  Expertise in natural resources, EO, and geospatial innovation
- Lund University (**LU**) – Sweden
  Climate and ecosystem modelling, sustainability science
- UCLouvain (**UCL**) – Belgium
  Applied remote sensing for agriculture and land use
- University of Tartu (**UT**) – Estonia
  Socio-economic systems, urban planning, and spatial analysis

Students will select two of these institutions, gaining access to world-class expertise, innovative technology, and a global network of partners. GEM offers a unique interdisciplinary curriculum that integrates geospatial science, environmental modelling, and policy applications, preparing MSc students to lead in the green and digital transitions.

GEM's **Associate Partners** include leading organisations in academia, industry, policy, and NGOs. They provide internships, guest lectures, co-supervision, and career mentoring, helping MSc students apply their skills to real-world challenges and build lasting professional networks.

Academic Associate Partners

GEM collaborates with universities and academies worldwide, offering students access to research networks, field sites, and co-supervised thesis opportunities. These partners contribute expertise in EO, sustainability, and spatial planning.

This academic network expands GEM's research capacity, international visibility, and joint projects while attracting top-tier students and researchers to regionally relevant challenges. For example, **The Quantitative Biosphere Dynamics group from the Technical University of Madrid** collaborates on research in the Mediterranean, providing MSc students with applications and challenges in environments exposed to climate change.

Industry Partners

GEM's industry partners include space tech firms, geospatial consultancies, and innovation labs. They provide internships, project collaboration, and career pathways in EO, GeoAI, and environmental analytics.

Network organisations: **EARSC**, **GeoForum Sweden**, and **SamGIS Skåne** provide market intelligence, access to professional networks, workshops, and industry events.

Private (space) companies and New Space companies: **Rabobank**, **KappaZeta**, **GIM Wallonie**, **Sweco**, **Airbus Defence and Space**, **Constellr GmbH**, **Aerospacelab**, and **Esri BeLux** provide access to innovative EO technologies in relevant and diverse application areas for GEM.

Commercialisation and innovation: **NL Space Campus** facilitates student access to commercialisation programmes such as ESA BIC, ESA Phi-Lab Netherlands, and ESA Technology Broker.

Policy and NGO Partners

Policy: **The Joint Research Centre (JRC) Food Security Unit** offers expertise in global agricultural monitoring, crop forecasting, and food security assessments aligned with EU policies like the Common Agricultural Policy.

International organisations: **GRID-Arendal** and **CIMMYT** offer global opportunities and expertise in environmental management, agricultural sustainability, and disaster resilience, providing real-world learning opportunities for MSc students.

Key benefits of the **GEM** programme are:

- Real-world experience GEM integrates academic learning with real-world challenges through internships, joint events, and applied research projects. MSc students collaborate with Associate Partners from industry, government, and NGOs to solve pressing environmental and societal problems. GEM graduates are in high demand with very high employment rates across different sectors
- A truly global and inclusive learning environment GEM attracts MSc students from over 75 countries and ensures equal access to top-tier education. Diversity is embedded in the curriculum, with interdisciplinary collaboration, open-source ICT tools, and inclusive policies that foster cultural exchange and equity. TheGEM international classroom provides you with a global network of peers that will benefit you for your whole career.
- Access to a global network of experts and organisations GEM MSc students benefit from direct engagement with Associate Partners across academia, industry, policy, and NGOs. This network offers internships, guest lectures, co-supervised theses, and career mentoring, supporting your lifelong professional development.

GEM degree profile

Degree profile of the Master of Science degree in Geo-information Science and Earth Observation for Environmental Modelling and Management (GEM)	
Type of degree & length	Multiple degree (120 ECTS-credits)
Institutions	University of Twente, Netherlands (ITC); University of Tartu, Estonia (UT); Université catholique de Louvain, Belgium (UCLouvain); Lund University, Sweden (LU)
Accreditation organisations	ITC - Dutch and the Belgium government through the Netherlands-Flanders Accreditation Office (NVAO); UT - Estonian Quality Agency for Higher and Vocational Education (EKKA); UCLouvain - Communauté Française de Belgique (CFB); LU - Swedish Higher Education Authority Universitetskanslersämbetet (UKA)
Period of reference	The curriculum is validated and approved for intakes between 2026 and 2031
Level	QF for EHEA: 2nd cycle; EQF level 7 – Masters degree (NLQF level 7 at ITC; EstQF level 7 at UT; CCES-FW-B level 7 at UCLouvain; SeQF level 7 at LU)

A Purpose

The programme. GEM tackles global challenges like climate change, biodiversity loss, and resource management through innovative geospatial solutions. Delivered by four leading universities, it integrates geoinformation, artificial intelligence (AI), and Earth observation (EO) to equip students with technical and socio-environmental skills that are in high demand in the job market. Through theoretical study, hands-on practice, and collaboration with geospatial sector partners, students tackle real-world issues such as sustainable agriculture, biodiversity conservation, & ecosystem restoration.

Graduate's personal development. GEM graduates acquire a unique set of technical & professional skills tailored to the job market. These include geospatial data analysis, programming in Python, R and SQL, advanced EO techniques, AI applications for environmental monitoring, and proficiency with tools like ArcGIS and QGIS. They also develop critical thinking, problem-solving, and the ability to manage complexity and ambiguity. Additionally, students gain experience in interdisciplinary teamwork, co-creating solutions with diverse societal actors, and maintaining an independent, ethical, and adaptive professional mindset.

Value to society. GEM graduates leverage vast quantities of geospatial data to effectively tackle climate adaptation, biodiversity conservation, and sustainable development challenges. By integrating technical expertise with an understanding of societal and environmental needs, GEM graduates achieve societal impact by contributing to Europe's leadership in fostering a greener, more resilient future.

B Characteristics

Disciplines and subject areas	• Geospatial technologies, AI, and EO [cloud computing, programming, workflows] (50%) • Environmental modelling and management for sustainable development (40%) • Spatial planning (10%)
General or specialist focus	Specialist: Geospatial technologies and EO for environmental modelling and management.
Orientation	This is an academic degree with a balance between applications and research.
Distinctive features	• Prestigious Erasmus+ joint masters programme with scholarships for the top applicants. • International mobility across at least two universities resulting in a double degree – one MSc diploma from the 1st year university and another from the 2nd year. • Four career-focused tracks: Geospatial Planner, Geospatial Analyst, Geospatial Developer, and Geospatial Modeller. • Compulsory internship in 1st year with partners from GEM's global network. • Career and professional development based on the "quadruple innovation helix." • Personal development portfolio for professional & career growth.

C Employability and further education

Employability	GEM graduates quickly find employment globally in the private sector/entrepreneurship (33%), academia (27%), governmental (12%), and non-governmental organisations (6%).
Further studies	Around 50% of GEM graduates have followed PhD programmes in topics including environmental science, computer science, big data, EO, and GeoAI.

D Education style

Learning & teaching approaches	A combination of lectures, tutorials, supervised practicals, lab work, field work, study trips, internship, self-study, project- & challenge-based collaborative work, and thesis.
Assessment methods	Written exams, oral exams, presentations, project reports, and final thesis.

E Programme competencies

Domain specific competencies

Technology and methods

- Capacity to effectively process & analyse EO data from Copernicus and other services, integrating multispectral, hyperspectral, & LiDAR technologies.
- Expertise in designing & implementing geospatial workflows using tools like ArcGIS, QGIS, and GEE.
- Ability to develop & execute spatial data analysis pipelines using Python & R programming languages.
- Proficiency in applying machine learning and AI techniques to model environmental phenomena.

Knowledge base

- Comprehensive understanding of advanced geospatial technologies, including GeoAI, digital twins, and remote sensing techniques.
- In-depth knowledge of environmental challenges, such as climate change mitigation, biodiversity conservation, and urban sustainability.
- Awareness of global and European environmental policies and frameworks, such as the European Green Deal and the UN Sustainable Development Goals.
- Familiarity with the principles & practices of sustainable resource management & environmental restoration.

Project management

- Capacity to deliver geospatial solutions for complex environmental problems.
- Capacity to test & validate geospatial solutions against user requirements.

Research

- Capacity to design & implement independent research on significant problems.
- Capacity to design & conduct research accounting for ethical, privacy, and security concerns

Generic competencies

Instrumental (cognitive, methodological, technical, and linguistic abilities)

- Capacity for analysis, synthesis, and problem solving in a complex world.
- Capacity to plan and manage projects, accounting for constraints.
- Capacity to communicate effectively and fluently by written, oral, and visual means.

Interpersonal (social skills - cooperating, communicating, and connecting)

- Capacity to work in interdisciplinary / international contexts, appreciating diversity and multiculturality.

Systemic (managing, leading, adapting, and working in professional scenarios)

- Capacity to work autonomously and produce the required output to deadlines.
- Capacity to adapt by adjusting plans and solutions in response to change.

Normative (the ability to reflect on your own values and accept those of others)

- Responsibility: take personal responsibility for decisions, actions, and failures.
- Respect: positive attention and recognition of fellow students and colleagues.
- Ethics: aware of professional behaviour and academic research standards.

F Programme learning outcomes

In addition to the programme competencies, the graduates of this programme will develop the following skills:

Geo-information science domain skills *Prepare students to apply geo-information science and Earth observation techniques to solve real-world environmental challenges, integrating diverse data and designing geospatial models that address global and European issues with social, cultural, and temporal awareness.*

1 Explain core geo-information science and Earth observation principles, concepts, methods, and techniques.
2 Use state-of-the-art geospatial technologies (GeoAI, cloud computing, EO, and GIS)
3 Integrate diverse types of (big) geographic and Earth observation data into useful and actionable information.
4 Design geospatial workflows and models.

Scientific knowledge and research skills *Equip students to conduct independent research in geospatial sciences and environmental modelling and management.*

5 Apply the FAIR principles and Open Science approaches in their research process.
6 Conduct independent scientific research.

Professional competence and multidisciplinary skills *Enable students to collaborate with diverse stakeholders and international teams, using geospatial tools to create sustainable solutions for complex environmental and societal challenges.*

7 Execute projects in collaboration with multiple stakeholders.
8 Collaborate in international, cross-disciplinary teams, ensuring teamwork, communication, cultural sensitivity, and adaptability in problem-solving.

Ethical, societal, and personal development skills *Strengthen students' ability to assess the ethical implications of geospatial technologies and promote lifelong learning for personal growth and skill enhancement.*

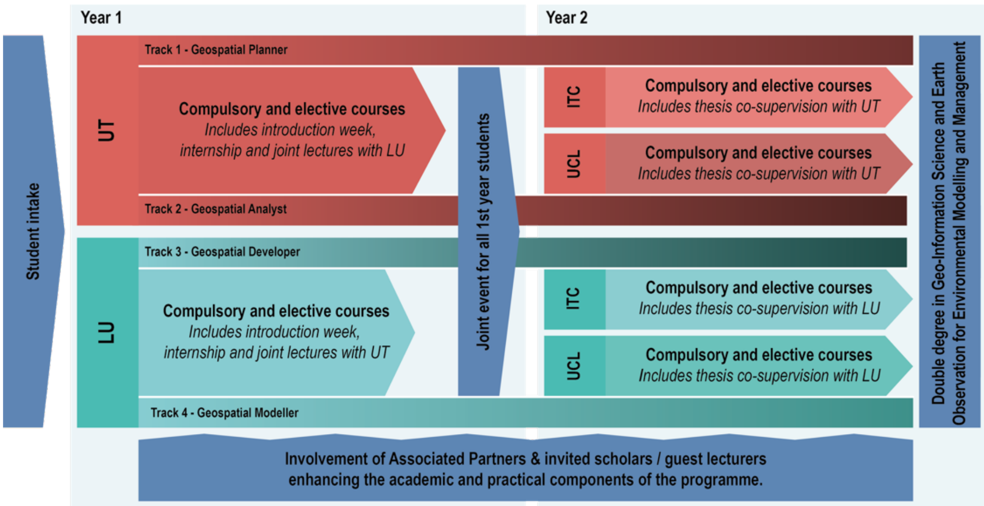
9 Evaluate ethical implications in various societal contexts, considering their impact on privacy, security, and equity.
10 Create a lifelong learning approach, incorporating personal growth and proactive updating of their skillsets.

Programme structure

Tomorrow's world is being shaped by those who harness data and technology to drive sustainable change. The GEM programme equips future leaders with the skills to model, manage, and restore socio-environmental systems across the globe.

Recent advances in Earth Observation (EO), GeoAI, and cloud computing have revolutionised our ability to monitor and model environmental systems. Yet, turning data into decisions requires skilled professionals who understand both the technology and the societal context. GEM offers an innovative MSc programme that prepares students to tackle global challenges - from climate resilience to sustainable land use - using geospatial intelligence.

The GEM Programme offers four career-focused tracks that combine geospatial science, environmental modelling, and societal applications. Each track addresses important societal and environmental challenges where there is high demand for relevant professional and technical skills.



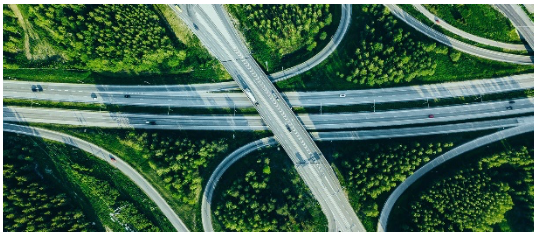
Each track includes foundational and advanced coursework, internships, and a co-supervised MSc thesis. At the end of the first year, students from all tracks will get together for a joint event that is co-organised by students and all four universities. Students study at two universities and engage with global experts and real-world challenges.

Specialised tracks

There are four tracks to choose from. These tracks integrate academic excellence from the four universities in geospatial science applied to societal challenges for a sustainable world.

TRACK	1. **Geospatial Planner (UT → ITC)** Focuses on using geospatial technologies for urban and environmental planning.	2. **Geospatial Analyst (UT → UCL)** Trains students to use geospatial data for land use and environmental monitoring.	3. **Geospatial Developer (LU → ITC)** Designed for students aiming to build custom geospatial solutions.	4. **Geospatial Modeller (LU → UCL)** Focuses on spatial modelling and simulation for food security and environmental sustainability.
YEAR 1	Year 1 at the University of Tartu covers spatial analysis, EO, and planning studios.	Year 1 at the University of Tartu includes EO and geovisualisation.	Year 1 at Lund University covers EO and data processing.	Year 1 at Lund University includes GIS programming, EO, and GeoAI.
YEAR 2	Year 2 at ITC-University of Twente includes participatory planning, ecosystem services, and entrepreneurship	Year 2 at UCLouvain focuses on spatial modelling, landscape ecology, and land monitoring.	Year 2 at ITC-University of Twente focuses on quantitative remote sensing and AI-driven geospatial applications.	Year 2 at UCLouvain covers Earth system monitoring, spatial dynamics, and bioscience modelling.

Track 1: Geospatial Planner (UT → ITC)



Shape the future of cities and landscapes with cutting-edge geospatial tools. This track combines spatial data science, remote sensing, and 3D modelling with planning studio experience and electives in mobility, migration, and bluegreen infrastructure. Year 2 deepens your expertise in GIS and Earth Observation for environmental assessment and participatory planning.

Ideal for students from Urban Planning, Geography, Environmental Science, or Civil Engineering, this track prepares you for roles such as Urban Planner, Environmental Policy Advisor, or Spatial Strategy Specialist—or for PhD research in sustainable spatial development.

Track 2: Geospatial Analyst (UT → UCL)

Turn data into insight for environmental and spatial decision-making. This track builds strong foundations in spatial analysis, remote sensing, and programming, with advanced training in land dynamics, landscape ecology, and smart Earth Observation technologies.

Designed for students from Geography, Environmental Science, Data Science, or Earth Sciences, it opens doors to careers as GIS Analyst, Environmental Data Scientist, or Remote Sensing Specialist, and provides a solid base for doctoral research in land use and environmental monitoring.

Track 3” Geospatial Developer (LU → ITC)

Build the next generation of geospatial technologies. This track blends programming, AI, and remote sensing to create smart solutions for environmental and spatial challenges. Year 1 focuses on geospatial AI and 3D data analysis, while Year 2 advances your skills in quantitative remote sensing and cloud-based geospatial systems.

Ideal for students with backgrounds in Computer Science, Geoinformatics, or Engineering, this track leads to careers as GIS Developer, Spatial Software Engineer, or AI-Powered Geospatial Specialist, and supports research in geospatial innovation.

Track 4: Geospatial Modeller (LU → UCL)

Model the planet to understand and predict change. This track equips you with advanced skills in spatial simulation, Earth system monitoring, and bioscience modelling. You’ll learn to apply geospatial AI and dynamic modelling techniques to tackle complex environmental problems across scales.

Suited to students from Environmental Science, Ecology, Earth Observation, or Climatology, this track prepares you for roles such as Environmental Modeller, Climate Data Scientist, or Earth Observation Researcher, and is an excellent launchpad for PhD studies in environmental modelling.

Key dates, teaching periods and teaching hours in the programme

Specific dates might change slightly depending on adjustments of academic calendars.

ITC-University of Twente, the Netherlands (ITC)

Academic calendar	
Event	**Date(s)**
Quartile 1	**September 2027 - November 2027**
Quartile 2	**November 2027 - February 2028**
Winter break	December 2027 - January 2028
Quartile 3	**February 2028 - April 2028**
Spring break	February 2028
Good Friday	14 April 2028
Easter Monday	17 April 2028
King's Day	27 April 2028
Quartile 4	**April 2028 - July 2028**
Liberation Day	5 May 2028
Ascension Day + Bridging Day	25 May 2028 and 26 May 2028
Whit Monday	5 June 2028
Summer Break	July 2028 - August 2028

Teaching periods	
1st period	08:45 - 10:30
2nd period	10:45 - 12:30
3rd period	13:45 - 15:30
4th period	15:45 - 17:30

There are coffee/tea breaks in the morning after the 1st period, and again in the afternoon after the 3rd period.

Lund University, Sweden (LU)

Academic calendar	
Event	**Date(s)**
Autumn semester	**31 August 2026 – 17 January 2027**
Arrival Days	Mid-August 2026
All Saints Day (Alla helgons dag)	31 October 2026
Christmas Day (Juldagen)*	25 December 2026
Boxing Day (Annandag Jul)*	26 December 2026
New Year's Day (Nyårsdagen)*	1 January 2027
Epiphany (Trettondedag)	6 January 2027
Spring semester	**18 January 2027 – 6 June 2027**
Easter Sunday (Påskdagen)*	28 March 2027
Easter Monday (Annandag påsk)*	29 April 2027
Walpurgis Night (Valborgsmässoafton)**	30 April 2027
Labour Day (Första maj)	1 May 2027
Ascension Day (Kristi himmelsfärds dag)	6 May 2027
Whit Sunday (Pingstdagen)	16 May 2027
Sweden's National Day (Nationaldagen)	6 June 2027
Midsummer Eve (Midsommarafton)	25 June 2027
Midsummer Day (Misommardagen)	26 June 2027

* Note on Christmas and Easter holidays: There is no official break in the academic calendar for Christmas or Easter, however in practice there is usually a break from classes over the Christmas/New Year's period and over the Easter period, including the public holiday days.

** Walpurgis Night (Valborgsmässoafton): This is an evening celebration, many workplaces have only half day off.

Teaching periods			
1st period	08:00 - 10:00	or	09:00 – 12:00
2nd period	10:00 - 12:00		
3rd period	13:00 - 15:00	or	13:00 – 16:00
4th period	15:00 - 17:00		

Université catholique de Louvain, Belgium (UCLouvain)

Academic calendar	
Event	**Date(s)**
1st semester and courses	**September 2027 – December 2027**
1st semester exam period	**January 2028**
French Community Day	27 September 2028
All Saints' Day	1 November 2028
Armistice	11 November 2028
New Year's Day	1 January 2028
2nd semester and courses	**February 2028 – May 2028**
2nd semester exam period	**June 2028**
Easter Monday	17 April 2028
Suspension of classes - Spring break	April - May 2028 (2 weeks)
Labor Day	1 May 2028
Ascension	25 May 2028
Pentecost	4 June 2028
Whit Monday	5 June 2028
National Holiday	21 July 2028
Assumption	15 August 2028

Teaching periods	
1st period	08:30 – 10:30
2nd period	10:45 – 12.45
3rd period	14:00 – 16:00
4th period	16:15 – 18:15

There are coffee/tea breaks in the morning after the 1st period, and again in the afternoon after the 3rd period

University of Tartu, Estonia (UT)

Academic calendar	
Event	**Date(s)**
Autumn semester	**31 August 2026 – 31 January 2027**
Welcome Days	Last week of August 2026
Christmas holiday	21 December 2026 - 3 January 2027
Christmas Eve	24 December 2026
Christmas Day	25 December 2026
Boxing Day	26 December 2026
New Year's Day	1 January 2027
Spring semester*	**8 February 2027 - 27 June 2027**
Winter holiday	1 February 2027 - 7 February 2027
Independence Day	24 February 2027
Good Friday	26 March 2027
Easter Sunday	28 March 2027
Spring Day (May Day)	1 May 2027
Whit Sunday	16 May 2027
Victory Day	23 June 2027
St. John's Day (Midsummer Day)	24 June 2027
Day of Restoration of Independence	20 August 2027
Summer holiday	28 June 2027 – 29 August 2027

* Officially, the spring semester lasts until the end of the last full week in August, thus no "typical classes" during July and August, but there may be fieldwork, internships, etc.

Teaching periods	
1st period	08:15 - 9:45
2nd period	10:15 - 11:45
3rd period	12:15 - 13:45
4th period	14:15 - 15:45
5th period	16:15 – 17:45

There are no fixed lunch or coffee/tea breaks. Lecturers can decide either 90 minutes in a row or with a break, and then it may last a full hour.

Overview of all Compulsory and Elective Courses for Tracks 1–4

Track 1 - Geospatial Planner

Year 1 – UT courses (60 EC)

Course	EC	Type
Spatial Data Studio	15 EC	Compulsory
Planning Studio	15 EC	Compulsory
Data Science in Remote Sensing	6 EC	Compulsory
Geospatial analysis with Python and R	6 EC	Compulsory
Internship	6 EC	Internship
3D Modelling and Analysis	6 EC	Elective
Spatial Databases	6 EC	Elective
Spatial Data on the Web	6 EC	Elective
Visual Geodata Mining	2 EC	Elective
Blue-green Infrastructures	4 EC	Elective
Demography, Global Migration and Contemporary Cities	6 EC	Elective
Geography, Communication and Spatial Mobility	6 EC	Elective

Year 2 – ITC courses (60 EC)

Course	EC	Type
MSc research proposal writing	5 EC	MSc thesis research
MSc research and thesis writing	35 EC	MSc thesis research
Advanced Professional & Scientific Skills	5 EC	Compulsory
Spatial analyses of ecosystem services	5 EC	Elective
Earth Observation and GIS for Strategic Environmental Assessment and Environmental Impact Assessment	5 EC	Elective
Digital Participatory Planning: Planning Support Systems for Decision Rooms, Web Applications, and Serious Games	5 EC	Elective
another ITC spatial planning elective replacing 1 of the 3 electives above	5 EC	Elective

Track 2 - Geospatial Analyst

Year 1 – UT courses (60 EC)

Course	EC	Type
Spatial Data Studio	15 EC	Compulsory
Planning Studio	15 EC	Compulsory
Data Science in Remote Sensing	6 EC	Compulsory
Geospatial analysis with Python and R	6 EC	Compulsory
Internship	6 EC	Internship
3D Modelling and Analysis	6 EC	Elective
Spatial Databases	6 EC	Elective
Spatial Data on the Web	6 EC	Elective
Visual Geodata Mining	2 EC	Elective
Blue-green Infrastructures	4 EC	Elective
Demography, Global Migration and Contemporary Cities	6 EC	Elective
Geography, Communication and Spatial Mobility	6 EC	Elective

Year 2 – UCL courses (60 EC)

Course	EC	Type
Master thesis	27 EC	MSc thesis research
Master thesis' accompanying seminar	3 EC	MSc thesis research
Smart technologies for environmental engineering (part A)	3 EC	Compulsory
Land monitoring by advanced Earth Observation (part A+B)	3+1 EC	Compulsory
Spatial modelling of land dynamics	3 EC	Compulsory
Landscape Ecology	4 EC	Compulsory
Applied Geomatics	4 EC	Compulsory
Advanced geoprocessing	5 EC	Compulsory
Project management	1 EC	Compulsory
Soil erosion and conservation	4 EC	Elective
Impact evaluation in agriculture	4 EC	Elective
other UCL geospatial data science courses	6 EC	Elective

Track 3 - Geospatial Developer

Year 1 – LU courses (60 EC)

Course	EC	Type
Programming for applications in GIS and Remote Sensing	15 EC	Compulsory
Geospatial Artificial Intelligence	7.5 EC	Compulsory
Collection and analysis of 3D Geodata	7.5 EC	Compulsory
Internship	15 EC	Internship
Satellite Remote Sensing	15 EC	Elective
Geographical Databases	7.5 EC	Elective
Spatial Analysis	7.5 EC	Elective

Year 2 – ITC courses (60 EC)

Course	EC	Type
MSc research proposal writing	5 EC	MSc thesis research
MSc research and thesis writing	35 EC	MSc thesis research
Advanced Professional & Scientific Skills	5 EC	Compulsory
Quantitative Remote Sensing of vegetation parameters	5 EC	Elective
Environmental Monitoring with integrated EO Data and Satellite Image Time Series	5 EC	Elective
Water and Carbon Dynamics in Ecosystems	5 EC	Elective
another ITC geospatial development elective replacing 1 of the 3 electives above	5 EC	Elective

Track 4 - Geospatial Modeller

Year 1 – LU courses (60 EC)

Course	EC	Type
Programming for applications in GIS and Remote Sensing	15 EC	Compulsory
Geospatial Artificial Intelligence	7.5 EC	Compulsory
Collection and analysis of 3D Geodata	7.5 EC	Compulsory
Internship	15 EC	Internship
Satellite Remote Sensing	15 EC	Elective
Geographical Databases	7.5 EC	Elective
Spatial Analysis	7.5 EC	Elective

Year 2 – UCL courses (60 EC)

Course	EC	Type
Master thesis	27 EC	MSc thesis research
Master thesis' accompanying seminar	3 EC	MSc thesis research
Smart technologies for environmental engineering (part A+B)	3+1 EC	Compulsory
Land monitoring by advanced Earth Observation (part A)	3 EC	Compulsory
Spatial modelling of land dynamics	3 EC	Compulsory
Applied Geomatics	4 EC	Compulsory
Process-based modelling in bioscience engineering	5 EC	Compulsory
Fundamentals of geographic and environmental modelling	5 EC	Compulsory
Algorithms in data science	5 EC	Elective
Introduction to the physics of the climate system and its modelling	5 EC	Elective
other UCL geospatial modelling courses	6 EC	Elective

Compulsory courses | Elective courses | Internship | MSc thesis research

Track 1 – Geospatial Planner

This section first lists all courses by track, with two university partners per track, and then provides the details of each course, partner by partner.

Courses in year 1 at University of Tartu

Course name	Type
Spatial Data Studio (15 EC)	Compulsory
Planning Studio (15 EC)	Compulsory
Data Science in Remote Sensing (6 EC)	Compulsory
Geospatial analysis with Python and R (6 EC)	Compulsory
Internship (6 EC)	Compulsory
3D Modelling and Analysis (6 EC)	Elective
Spatial Databases (6 EC)	Elective
Spatial Data on the Web (6 EC)	Elective
Visual Geodata Mining (2 EC)	Elective
Blue-green Infrastructures (4 EC)	Elective
Demography, Global Migration and Contemporary Cities (6 EC)	Elective
Geography, Communication and Spatial Mobility (6 EC)	Elective

Courses in year 2 at ITC-University of Twente

Course name	Type
MSc research proposal writing (5 EC)	Compulsory
MSc research and thesis writing (35 EC) (5 EC)	Compulsory
Advanced Professional & Scientific Skills (5 EC)	Compulsory
Spatial analysis of ecosystem services (5 ECo	Elective
Earth Observation and GIS for SEA….(5 EC)	Elective
Digital Participatory Planning: Planning Support Systems for Decision Rooms, Web Applications, and Serious Games (5 EC)	Elective
Another ITC spatial planning elective replacing 1 of the 3 electives above (5 EC)	Elective

Track 2 - Geospatial Analyst

Courses in year 1 at University of Tartu

Course name	Type
Spatial Data Studio (15 EC)	Compulsory
Planning Studio (15 EC)	Compulsory
Data Science in Remote Sensing (6 EC)	Compulsory
Geospatial analysis with Python and R (6 EC)	Compulsory
Internship (6 EC)	Compulsory
3D Modelling and Analysis (6 EC)	Elective
Spatial Databases (6 EC)	Elective
Spatial Data on the Web (6 EC)	Elective
Visual Geodata Mining (2 EC)	Elective
Blue-green Infrastructures (4 EC)	Elective
Demography, Global Migration and Contemporary Cities (6 EC)	Elective
Geography, Communication and Spatial Mobility (6 EC)	Elective

Courses in year 2 at Université catholique de Louvain

Course name	Type
Master thesis (27 EC)	Compulsory
Master thesis' accompanying seminar (3 EC)	Compulsory
Smart technologies for environmental engineering (part A) (3 EC)	Compulsory
Land monitoring by advanced Earth Observation (part A+B) (3+1 EC)	Compulsory
Spatial modelling of land dynamics (3 EC)	Compulsory
Applied Geomatics (4 EC)	Compulsory
Landscape Ecology (4 EC)	Compulsory
Advanced geoprocessing (5 EC)	Compulsory
Project management (1 EC)	Compulsory
Soil erosion and conservation (4 EC)	Elective
Impact evaluation in agriculture (4 EC)	Elective
other UCL geospatial data science courses (6 EC)	Elective

Track 3 - Geospatial Developer

Courses in year 1 at Lund University

Course name	Type
Programming for applications in GIS and Remote Sensing (15 EC)	Compulsory
Geospatial Artificial Intelligence (7.5 EC)	Compulsory
Collection and analysis of 3D Geodata (7.5 EC)	Compulsory
Internship (15 EC)	Compulsory
Satellite Remote Sensing (15 EC)	Elective
Geographical Databases (7.5 EC)	Elective
Spatial Analysis (7.5 EC)	Elective

Courses in year 2 at ITC-University of Twente

Course name	Type
MSc research proposal writing (5 EC)	Compulsory
MSc research and thesis writing (35 EC)	Compulsory
Advanced Professional & Scientific Skills (5 EC)	Compulsory
Quantitative Remote Sensing of vegetation parameters (5 EC)	Elective
Environmental Monitoring with integrated EO Data and Satellite Image Time Series (5 EC)	Elective
Water and Carbon Dynamics in Ecosystems (5 EC)	Elective
Another ITC geospatial development elective replacing 1 of the 3 electives above (5 EC)	Elective

Track 4 - Geospatial Modeller

Courses in year 1 at Lund University

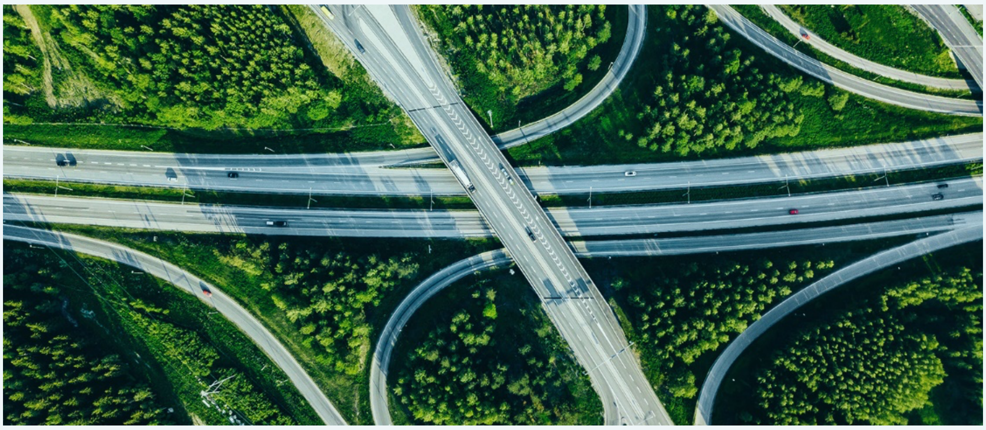
Course name	Type
Programming for applications in GIS and Remote Sensing (15 EC)	Compulsory
Geospatial Artificial Intelligence (7.5 EC)	Compulsory
Collection and analysis of 3D Geodata (7.5 EC)	Compulsory
Internship (15 EC)	Compulsory
Satellite Remote Sensing (15 EC)	Elective
Geographical Databases (7.5 EC)	Elective
Spatial Analysis (7.5 EC)	Elective

Courses in year 2 at Université catholique de Louvain

Course name	Type
Master thesis (27 EC)	Compulsory
Master thesis' accompanying seminar (3 EC)	Compulsory
Smart technologies for environmental engineering (part A+B) (3+1 EC)	Compulsory
Land monitoring by advanced Earth Observation (part A) (3 EC)	Compulsory
Spatial modelling of land dynamics (3 EC)	Compulsory
Applied Geomatics (4 EC)	Compulsory
Process-based modelling in bioscience engineering (5 EC)	Compulsory
Fundamentals of geographic and environmental modelling (5 EC)	Compulsory
Algorithms in data science (5 EC)	Elective
Introduction to the physics of the climate system and its modelling (5 EC)	Elective
other UCL geospatial modelling courses (6 EC)	Elective

Courses in year 1 at University of Tartu, Estonia

Track 1 – Geospatial Planner | Track 2 – Geospatial Analyst



Spatial Data Studio	
Course code	LTOM.02.011
Course type	Compulsory (Track 1 & Track 2)
Period	September 2026 - January 2027
Credits	15
Coordinator	Evelyn Uuemaa
Keywords	spatial data | data quality | geospatial analysis | map design
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.011/details

Description

The students will learn about the variety of spatial data types, formats, and standards of relevant software and data used in GIS. Combined theoretical and practical study, the course has a strong emphasis on developing practical skills in order to get students fluent in working with data.

The lab sessions comprise ⅔ of the course. Main software used in the Spatial Data Studio will be QGIS, Python and PostgreSQL. Remainder ⅓ is covered by lectures of theoretical part and seminars where students present their work. The course will be led by PhD Evelyn Uuemaa and PhD Alexander Kmoch. The course aims to enable the students to effectively acquire, manage, and work with spatial and spatio-temporal data.

In the first part of the studio, students will apply methods of data acquisition in different fields and learn spatial data collection methods. Students will learn how to find, download, clean, and organise data from different data sources into useful data structures. The students will learn about scale, projection, accuracy, and precision of spatial data, and how these relate to the reliability and uncertainties of spatial data, thus, enabling them to use spatial data appropriately. They will also learn how to visualise the spatial data.

In the second part, students will work with various datasets (urban, elevation, climate, soil, land use) and perform different spatial analysis in vector and raster format.

Learning outcomes

- Understands and is able to apply methods of data acquisition in different fields
- Is able to design and manage spatial database
- knows the formats and software of important spatial data and databases
- Knows spatial coordinate systems and is able to choose correct coordinate system according to purpose
- Is able to use and create metadata
- Knows main spatial data standards and is able to estimate the spatial data quality
- Is able to independently pose and solve problem based on spatial data
- Is able to perform geoprocessing and basic spatial analysis
- Is able to communicate and visualise the spatial data in a meaningful way

Content

- Introduction, main data types in GIS
- Coordinate systems and map projections
- Open Geospatial Consortium and distributed geodata services
- Spatial data quality and data aggregation
- Map design
- Introduction to remote sensing
- Descriptive statistics and data classification in GIS
- Spatial urban data and geoprocessing

Spatial Data Studio		
▪ Global environmental data and raster algebra		
Entry requirements		
Basic statistics; GIS experience (ArcGIS or QGIS); Ideally some geographical background		
Teaching and learning approach		
We combine theoretical lectures with hands-on lab sessions. Each topic will end with a seminar. Seminars are either based on student presentations and discussions followed afterwards, or debates on relevant topics. We encourage taking part in hackathons that are organised by the course managers or Tartu Science Park.		
Time allocation in hours per activity		
Lecture [contact]	20	
Supervised practical [contact]	40	
Tutorial [contact]	84	
Written/oral test	56	
Individual assignment	96	
Group assignment	38	
Self-study	56	
Sum	**390**	
Assessment		
Examiners	Evelyn Uuemaa, Alexander Kmoch, Raivo Aunap	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills exam 1	5	individual
Practical skills exam 2	5	individual
Practical skills exam 3	5	individual
Practical skills exam 4	5	individual
Practical skills exam 5	5	individual
Practical skills exam 6	5	individual
Practical skills exam 7	5	individual
Practical skills exam 8	5	Individual
Practical skills exam 9	5	Individual
Practical skills exam 10	5	Individual
Test	25	Individual
Final project	25	Individual

Planning Studio	
Course code	LTOM.02.010
Course type	Compulsory (Track 1 & Track 2)
Period	February 2027 - May 2027
Credits	15
Coordinator	Siiri Silm
Keywords	Spatial planning | GIS | Statistical analysis | Designing maps
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.010/details

Description

This course aims to provide knowledge on how to use spatial data and analysis in urban and regional planning. During the course, students will gain practical experience in the process of preparing a spatial plan.

Students will learn the modern planning theoretical framework and methods, and apply this knowledge in preparing a planning project as group work. The general topic of each group project is given by the lecturers. At the end of the course, the group work will be presented and defended. The course is divided into three stages (theoretical context of spatial planning, empirical analysis, and preparation of a planning solution) and is taught by different lecturers.

1. Contemporary spatial planning
In the first phase, students acquire knowledge of the basic concepts of planning and the most relevant topics in contemporary spatial planning (for example, sustainability, mobility, etc.). In addition to this, students become acquainted with the main topics, regulations, and spatial plans of the area under study. Working teams are formed. By the end of the first phase, the main goal and task of the Planning Project for each group are formulated.

2. Statistical analysis
In the second phase, each group performs a quantitative analysis based on their specific group-work task. This is done using statistical analysis methods. The goal is to conduct an empirical data analysis and implement the results in the Planning Project. At the end of the second phase, students present their analysis results.

3. Compilation of a spatial plan
In the third phase, the results of the statistical analysis provide the basis for the sketch plans. The spatial plan and policy recommendations are developed based on the goals and analysis of the results. Basic visualisation principles are taught in the context of urban planning. A zoning map is designed, together with an explanatory text of a spatial plan, which sets out the goals for the spatial development.

Learning outcomes

- knows the principles of contemporary spatial planning
- is able to use relevant datasets for preparing spatial plans
- has an overview of the main quantitative and qualitative methods used in spatial planning
- is able to select, apply and evaluate appropriate GIS tools, visual and quantitative methods for data analysis and spatial planning
- is able to propose policy recommendations and planning solutions based on the analysis
- is able to compile spatial plan and design planning maps
- understands the concept of participatory planning and is able to present and defend his/her planning project in public

Planning Studio

- has been involved in group work
- has skills for academic writing

Content

- Modern concepts and issues in contemporary spatial planning. Spatial planning as a process and its different stages.
- Different data sources for spatial planning
- Quantitative data analysis and statistics
- Visual language of spatial planning.
- Compilation of planning document and a spatial plan map, defence.

Entry requirements

Basic statistics; GIS experience (maps)

Teaching and learning approach

We apply a mix of different teaching approaches which includes both individual and group work. The teaching includes (e-)lectures, (e-)seminars, computer-lab sessions, public presentation simulation, fieldtrip, roundtable discussion all combined in problem-based project learning.

Time allocation in hours per activity

Lecture [contact]	22
Supervised practical [contact]	10
Tutorial [contact]	22
Individual assignment	70
Study trip [contact]	4
Group assignment	225
Self-study	37
Sum	**390**

Assessment

Examiners: Siiri SIlm, Ago Tominga, Ingmar Pastak, Pille Metspalu

Test type (descriptive)	Weight of the test (%)	Individual or Group test
Literature overview	2	Group work
Mobility plan analysis	3	Individual
Empirical study	30	Group work
Group-work contribution	15	Individual
Review of empirical study	0	Group work
Planning project	30	Group work
Spatial plan map	20	Individual

Data Science in Remote Sensing	
Course code	LTTO.00.027
Course type	Compulsory (Track 1 & Track 2)
Period	September 2026 - December 2026
Credits	6
Coordinator	Krista Alikas
Keywords	Remote Sensing | Copernicus | Ecosystem | Forestry | Waterbodies | Agriculture | Environment
Hyperlink	https://ois2.ut.ee/#/courses/LTTO.00.027/details

Description

The course will focus on various methods and applications used in remote sensing of environment.

An overview will be given about passive and active remote sensing. Students will learn how to combine data from various origin and sources to analyse the changes in environment.

At the beginning of the course, students can select a topic which they will start to solve in a smaller group.

Every group has a supervisor. The course is based on a problem-based learning method.

Additionally, lectures about various remote sensing applications will be held.

Learning outcomes

- students have the overview about principles used in passive, radar and lidar remote sensing and their respective application fields
- knows the principles of spectral measurements (knows the terms spectrometer, radiance, irradiance, reflectance, atmospheric correction, calibration)
- knows the principles in water remote sensing (bio-optical modelling, adjacency effect)
- knows the principles in vegetation remote sensing (optical properties of the leaf, contribution of various features to the reflectance, leaf angles, various indices)
- student knows how to download, process, and analyse remote sensing and possibly ancillary data and apply this knowledge to solve various exercises
- they know how to plan and conduct groupwork

Content

- Introduction to Remote Sensing
- Introduction to spectral measurements
- Databases
- Machine learning models
- RS of plant canopies
- RS applications in forestry
- water RS
- Validation of EO data
- Multi-angle remote sensing

Entry requirements

None

Teaching and learning approach

We apply a problem-based project learning which is accompanied by weekly lectures.

Data Science in Remote Sensing		
Time allocation in hours per activity		
Lecture [contact]	16	
Supervised practical [contact]	22	
Tutorial [contact]	2	
Written/oral test	6	
Individual assignment	10	
Group assignment	74	
Self-study	26	
Sum	**156**	
Assessment		
Examiners	Krista Alikas, Kaupo Voormansik, Jan Peter George, Kersti Kangro, Mait Lang, Jan Pisek, Velle Toll, Ian-Andreas Rahn, Mirjam Uusõue, Oleksandr Borysenko	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	65	individual
Weekly small assignments	10	Individual
Oral presentation & written report	25	Small groups

Geospatial Analysis with Python and R	
Course code	LTOM.02.041
Course type	Compulsory (Track 1 & Track 2)
Period	February 2027-May 2027
Credits	6
Coordinator	Holger Virro, Alexander Kmoch, Anto Aasa
Keywords	Python | R | geospatial | programming | data analysis
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.041/details

Description

Introductory course on concepts, skills, and tools for working with the Python and R scripting environments. Acquaintance with practical Python and R libraries for everyday scientific and professional GIS use, with a focus on automating different standard GIS-related tasks that support clear documentation of methods and productivity.

These lessons assume no prior knowledge of the skills or tools. It is a hands-on teaching course, so the majority of this course will be together in front of a computer and working on exercises.

Learning outcomes

- Knows basic concepts, skills, and tools for working with the Python and R scripting environments
- Compiles an overview of practical Python and R libraries for everyday scientific and professional GIS use
- Understands how to make use of integration of Python and R environments from other software packages
- Is able to apply to solve common data-related tasks using Python and R in concrete GIS projects
- Is competent of using spatial and non-spatial data in order to answer a research question
- Knows how to conduct and automate different standard GIS-related tasks that support clear documentation of methods in the Python and R scripting environments

Content

- Setup environments and notebooks; Recap Getting started Python and R.
- Spatial data model; Geometric Objects; Shapely.
- Working with GeoDataFrames; Managing projections.
- making spatial queries and joins.
- Reclassifying data.
- Working with raster data
- Visualization, making static and interactive maps.

Entry requirements

Basic statistics; GIS experience; basic programming skills

Teaching and learning approach

The majority of this course will be spent in front of a computer learning to program in the Python and R languages and working on exercises.

Time allocation in hours per activity

Tutorial [contact]	64
Individual assignment	48
Self-study	44
Sum	**156**

Geospatial Analysis with Python and R		
Assessment		
Examiners	Alexander Kmoch, Anto Aasa, Holger Virro	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills exam	12.5	individual
Practical skills exam	12.5	individual
Practical skills exam	12.5	individual
Practical skills exam	12.5	individual
Practical skills exam	50	individual

Internship		
Course code	LTOM.02.054	
Course type	Compulsory (Track 1 & Track 2)	
Period	February 2027 – August 2027	
Credits	6	
Coordinator	Kristina Sohar, Merle Muru, Ats Remmelg	
Keywords	Internship	
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.054/details	
Description		
The aim of work placement is to broaden the understanding of student about the work with spatial data in practice and about the arrangement of work in organizations and teams as well as to give the student practical experiences of solving real life tasks in teamwork.		
Learning outcomes		
▪ get the understanding of the use of spatial data in practice: the architecture and functions of spatial data sets and their applied values ▪ understand the work arrangement and team management in organizations working with spatial data ▪ know the GIS tools used in practice and be able to solve some practical tasks concerning spatial processes ▪ obtain experience about working with colleagues and in teams ▪ be able to analyse and evaluate the obtained skills and experiences during work placement and defend the report in front of the committee		
Content		
▪ The student will work in an enterprise, public sector office or nongovernmental organization and solve tasks about spatial processes with GIS tools in teams. After the work placement, the student will defend the report of work placement in front of the committee.		
Entry requirements		
Basic GIS experience		
Teaching and learning approach		
Individual internship (minimum three weeks) in an enterprise/organisation with introductory seminars and concluding presentation at the university.		
Time allocation in hours per activity		
Seminar [contact]	8	
Individual internship	131	
Self-study	17	
Sum	**156**	
Assessment		
Examiners	Kristina Sohar, Merle Muru, Ats Remmelg	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Work plan/contract	0	individual
Evaluation by employer received	40	individual
Report	40	individual
Defence	20	individual

3D Modelling and Analysis	
Course code	LTOM.02.042
Course type	Elective (Track 1 & Track 2)
Period	September 2026 – November 2026
Credits	6
Coordinator	Merle Muru, Raivo Aunap
Keywords	Surface models | point clouds | 3D | visualisation
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.042/details

Description

Aim of the course is to give basic knowledge and skills of the use of 3D geospatial data and models in terrain and surface analysis and planning.
The course consists of combined theoretical and practical study. The topics are: creation and analysis of terrain and surface models; static and dynamic models and visualisations; visibility analysis; hydrological and flood analysis; 3D modelling, analysis and visualisation in city and landscape planning.

Learning outcomes

- Knows primary principles of handling and presenting 3D data in terrain and surface, incl. city modelling
- Knows primary data structures used in 3D modelling
- Understands and is able to apply basic methods and techniques of 3D modelling and analysis of terrain and various surfaces
- Is able to visualize modelling results in 3D scenes
- Knows implementations of 3D modelling and analysis

Content

- Terrain/relief representation and elements terrain models
- Lidar technique and point clouds
- Basics of landscape 3D visualization
- City and buildings 3D models
- Sea level change and flood modelling
- Hydrological modelling

Entry requirements

Basic GIS experience

Teaching and learning approach

Mainly computer labs combined with lectures, seminars, in form of classroom and e-learning, individual project.

Time allocation in hours per activity

Lecture [contact]	4
Supervised practical [contact]	33
Seminar [contact]	4
Individual assignment	30
Self-study	85
Sum	**156**

Assessment

Examiners	Merle Muru, Raivo Aunap

3D Modelling and Analysis		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Moodle assignments	0	individual
Seminar presentation	10	individual
Individual research/essay	20	individual
Portfolio	70	individual

Spatial Databases	
Course code	LTOM.02.040
Course type	Elective (Track 1 & Track 2)
Period	September 2026 - January 2027
Credits	6
Coordinator	Valentina Sagris
Keywords	Database | Spatial data and functions | postgreSQL and PostGIS
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.040/details

Description

The objectives of the course are:

- to review the basics of relational database theory.
- to learn how spatial data is represented in conventional databases and related standards; to learn how to manage and analyse spatial data in databases.
- to learn how to access and use spatial data from databases with different client applications.
- to apply theoretical knowledge in creating and working with geospatial databases and publishing spatial data with PostgreSQL/PostGIS

Students build on general database theory and how spatial data is incorporated. They are introduced to standards for encoding geometry and spatial reference systems in the database realm. This course is about designing a database and working with geospatial data. Students learn spatial functions that form the building blocks of more sophisticated analytical models. Accessing own database with desktop and web applications is an important part of practical exercises.

Learning outcomes

- design and create databases using PostgreSQL/PostGIS
- manage data and spatial data in PostgreSQL/PostGIS databases
- perform geospatial analysis in the spatial database

Content

- Learn more about Spatial Data Infrastructure (SDI), its components and standards
- Introduction to spatial data modeling with GML and data specifications
- Geospatial modelling using Unified Modelling Language (UML)
- Using Geography Markup Language (GML) as a standard for geospatial data encoding and transporting through the web
- Using GIS software as clients to SDI
- publish and styling maps of raster and vector data in the web

Entry requirements

GIS experience (ArcMap, QGIS); geoinformation background

Teaching and learning approach

We apply a mix of different teaching approaches which includes process-based instruction, inquiry teaching, reflective teaching (learning by doing), e-learning, individual project work.

Time allocation in hours per activity

Lecture [contact]	18
Supervised practical [contact]	28
Seminar	8
Individual assignment	102
Sum	**156**

Spatial Databases		
Assessment		
Examiners	Valentina Sagris, Alexander Kmoch	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Assignments	60	individual
Seminar presentation	20	individual
Final test	20	individual

Spatial Data on the Web	
Course code	LTOM.02.071
Course type	Elective (Track 1 & Track 2)
Period	February 2027 - May 2027
Credits	6
Coordinator	Alexander Kmoch
Keywords	Spatial data infrastructures | web mapping
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.071/details

Description

This course provides a comprehensive introduction into modern web-based geospatial technologies, spanning traditional spatial data infrastructures (SDI) to contemporary web mapping and cloud-native geospatial solutions.

We will develop theoretical understanding and practical implementation skills in web-based spatial data management, standardization, access, sharing, visualization, and processing, The course provides an overview of the evolution from conventional SDIs to the modern geospatial ecosystem.

Learning outcomes

- demonstrate handling of web-based geospatial concepts and technologies, understand and implement OGC web services and standards and cloud-native geospatial technologies for mapping, visualising, discovering and sharing spatial datasets
- have proficiency in spatial metadata management
- to know which technologies and services to use for which use cases e.g. visualising spatial data on the web vs analysing feature data.
- have practical skills in both consuming and providing geospatial web services and develop a web mapping application, while understanding the theoretical frameworks that underpin these technologies.

Content

- geospatial metadata management, including catalogue services and metadata creation based on international standards
- using GeoServer for spatial data publication, using WMS functionality and map styling using SLD styling
- data modeling concepts including Geography Markup Language (GML) and Unified Modelling Language (UML)
- integrating various data delivery methods including WMS, GeoJSON, REST APIs, and vector tiles (MVT)
- cloud-native geospatial concepts

Entry requirements

While prior programming experience is not mandatory, it is highly preferred. Students without any prior coding experience will have to be ready to put extra work into the assignments.

Teaching and learning approach

We apply a mix of theory, e-learning, practical lab sessions, individual and group work.

Time allocation in hours per activity

Lecture [contact]	6
Supervised practical [contact]	14
Tutorial [contact]	14
Individual assignment	30

Spatial Data on the Web		
Self-study	92	
Sum	**156**	
Assessment		
Examiners	Alexander Kmoch, Valentina Sagris, Ats Remmelg	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Quiz	10	individual
Practical skills exam	10	individual
Practical skills exam	20	individual
Practical skills exam	30	individual
Practical skills exam	30	small group

Visual Geodata Mining

Course code	LOOM.02.349
Course type	Elective (Track 1 & Track 2)
Period	March 2027 - April 2027
Credits	2
Coordinator	Jukka Matthias Krisp
Keywords	Geodata | visualisation | visual data mining
Hyperlink	https://ois2.ut.ee/#/courses/LOOM.02.349/details

Description

The course deals with spatial and visual data mining techniques in multivariate data sets.

Learning outcomes

- understand applications and methods to "visual data mining"
- assess visual data mining tools (anticipated "GeoVista/GeoViz")
- understand the overall "visual mining process"
- use methods and applications of "visual spatial data mining"
- evaluate methods of "visual spatial data mining

Content

- The course will be giving brief overview of visual geodata mining. During the course students will get reading materials which later on will follow with discussion.
- Course also contain exercises with visual data mining programme GeoVista/GeoViz which will be held in the computer room and supervised by prof. Krisp

Entry requirements

None

Teaching and learning approach

We apply a mix of different teaching approaches which includes e-lecture, seminars and problem-based learning supported by computer practicals.

Time allocation in hours per activity

Lecture [contact]	12
Tutorial [contact]	3
Individual assignment	33
Self-study	4
Sum	**52**

Assessment

Examiners	Jukka Matthias Krisp	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Exercise	50	individual
Exercise	50	individual

Blue-green Infrastructures	
Course code	LTOM.02.051
Course type	Elective (Track 1 & Track 2)
Period	September 2026 - December 2026
Credits	4
Coordinator	Margit Kõiv-Vainik
Keywords	Blue-green infrastructures, climate change mitigation, urban environment
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.051/details

Description

Blue-Green Infrastructures offer a feasible, economical, and valuable solution for urban regions facing challenges of climate change. This course gives an overview of BGI-s and their functions in urban environment. Introduces principles, applications, and policies of and related to BGI-s. The course deals with climate change and its consequences, with the flood risks and its management and with pollution control using complex sustainable approaches. The course describes measures to climate change adaption, principles of sustainable urban drainage systems (SUDS), introduces different SUDS solutions for stormwater and flood risk management. This course demonstrates how BGI-s techniques function and how they can contribute to climate adaptation strategy.

Learning outcomes

- know the definition and different types of BGI-s.
- recognise the best practices of BGI-s.
- understand the range of benefits (water-related, climate change adaptation and biodiversity (ecosystem services), aesthetic, and societal) of using BGI-s.
- know the principles of successful implementation of BGI-s and various elements and functions of BGI-s.
- identify the characteristics of BGI-s that make them ideal for climate change adaptation.
- have an overview of the challenges and barriers to implementation BGI-s in dense urban area.
- understand the planning process designed to develop a comprehensive BGI-s planning and implementation strategy.
- know how to integrate BGI-s to the circular economy.

Content

- Climate change and urbanisation problems and mitigation
- Blue-green infrastructure and legistlation
- Sustainable stormwater management solutions
- Examples of design from different countries

Entry requirements

None

Teaching and learning approach

Lectures and quest lectures together with seminars, group work and student presentations.

Time allocation in hours per activity

Lecture [contact]	6
Seminar [contact]	20
Group work	38
Self-study	40
Sum	**104**

Blue-green Infrastructures		
Assessment		
Examiners	Margit Kõiv-Vainik, Gen Mandre, Valdo Kuusemets	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Seminar participation	10	individual
individual presentation	25	individual
Report	40	group
Presentation	25	group

Demography, Global Migration and Contemporary Cities	
Course code	LTOM.02.030
Course type	Elective (Track 1 & Track 2)
Period	October 2026 - January 2027
Credits	6
Coordinator	Tiit Tammaru
Keywords	Migration | segregation | contemporary cities | urban change
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.030/details

Description

The aim of this course is to get overview of the global population trends and their relationship to urban development and planning.

The course will combine international perspective to migration with the local demographic processes, and place European and Estonian urban trends within the context of the global urbanization. The main migration and demographic approaches and concepts will be discussed: types of migration and intra-urban residential mobility, socio-economic and ethnic segregation, lifecourse theories, transnationalism.

Practical exercises and discussions will be carried out during the course, with an aim to develop students' analytical skills and capabilities to independently carry out fieldwork in the field of urban geography. Different pedagogic methods will be applied to combine individual exercises with teamwork, discussion seminars with lectures. During the course meetings will be organized with the key persons among Estonian urban and immigration policy implementors. In this way students will be able to combine theoretical knowledge with the practical outputs.

Learning outcomes

- understand the development of global population trends in different regions of the globe
- understand the relationship between migration, social inequalities, and urban spatial segregation
- know the main concepts in demography, migration, and segregation
- obtain analytical skills in the field, including composing population forecast, measure segregation, and evaluate life quality in urban neighbourhoods
- be able to place Estonia and Europe among the global framework of urbanization and migration trends
- obtain practical knowledge on urban and migration policy development in Estonia

Content

- Migration flows and migration policies
- Population projection
- Inequalities, vicious circles
- Residential segregation, school segregation, workplace segregation, leisure time segregation
- Processes of neighbourhood transition (gentrification, suburbanisation)
- Interventions
- Integration
- Urban analysis of Asian cities

Entry requirements

None

Teaching and learning approach

Demography, Global Migration and Contemporary Cities		
We use different teaching methods: (e-)lectures, seminars, practicums, individual and group work. Home assignments are done in various ways to give an insight of different methods: practical exercises, summary based on reading materials, poster session.		
Time allocation in hours per activity		
Lecture [contact]	10	
Supervised practical [contact]	4	
Tutorial [contact]	10	
Written/oral test	2	
Group assignment	72	
Self-study	58	
Sum	**156**	
Assessment		
Examiners	Tiit Tammaru, Anneli Kährik, Kadi Kalm	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Home assignment 1	10	small groups
Home assignment 2	10	small groups
Home assignment 3	10	small groups
Home assignment 4	20	individual
Written exam	50	individual

Geography, Communication and Spatial Mobility	
Course code	LTOM.02.050
Course type	Elective (Track 1 & Track 2)
Period	March 2027 –May 2027
Credits	6
Coordinator	Anto Aasa
Keywords	geography | ICT, mobile positioning | mobility analysis | social media
Hyperlink	https://ois2.ut.ee/#/courses/LTOM.02.050/details

Description

The aim of the course is to introduce the theoretical and methodological aspects of spatial mobility, information society and Smart City.

Special focus is on mobile telephone and ICT-based research methods and applications used in urban planning. Ethical issues in the use of ICT-based big data and differences arising from culture and context are addressed.

Learning outcomes

- understands terminology and concepts of spatial mobility
- is aware how spatial mobility, social mobility and activities of individuals are interrelated
- is aware of the impacts of information and communication technologies (ICT) on spatial mobility
- knows the data collection methods of spatial mobility
- has an overview of passive mobile positioning data
- has an overview of active positioning methods and smartphone-based data
- is able to measure individuals' spatial mobility with mobile positioning
- understands the concepts of information society and Smart City
- has an overview of social media data and research applications
- is able to use mobile phone and social media-based information sources for urban studies and planning

Content

- Information society
- Geography of information society
- Spatial mobility, social mobility, activities, and travel
- Methods for collecting movement data
- Collecting movement data with mobile phones - passive and active mobile positioning data in urban studies and transportation.
- BIG data and initiatives with mobile phones
- Analysing spatial mobility with mobile positioning data
- information and communication technologies (ICT) and society
- Spatial mobility and ICT
- Active mobile positioning and data collection with Smartphone
- Business plan exercise with mobile big data
- Information society and social media

Entry requirements

Basic statistics; Spatial analysis

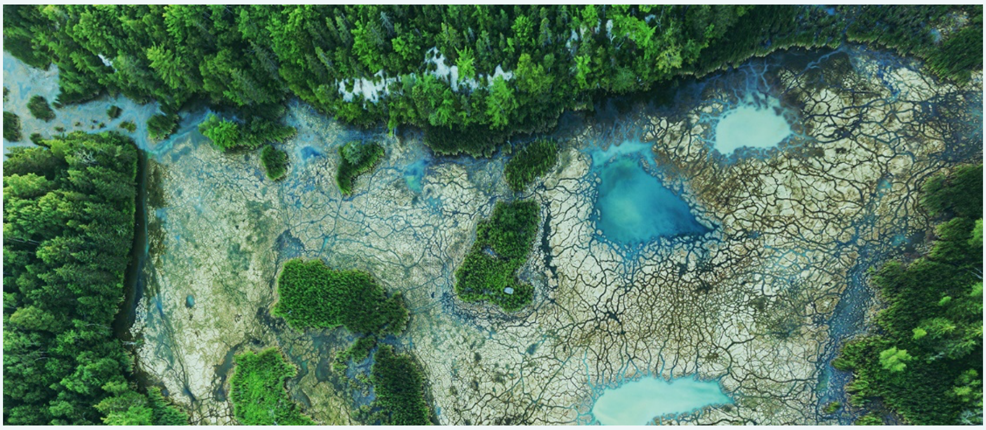
Teaching and learning approach

Lectures, practical sessions, independent work, seminars

Geography, Communication and Spatial Mobility		
Time allocation in hours per activity		
Lecture [contact]	24	
Supervised practical [contact]	4	
Individual assignment	36	
Group assignment	50	
Self-study	42	
Sum	**156**	
Assessment		
Examiners	Anto Aasa, Martin Haamer	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills exam 1	10	individual
Practical skills exam 2	15	group work
Practical skills exam 3	15	group work
Practical skills exam 4	15	group work
Practical skills exam 5	15	individual
Written test	30	individual

Courses in year 1 at Lund University, Sweden

Track 3 – Geospatial Developer | Track 4 – Geospatial Modeller



Programming for applications in GIS and Remote Sensing	
Course code	NGEN20
Course type	Compulsory (Track 3 & Track 4)
Period	September 2026 - November 2026
Credits	15
Coordinator	Per-Ola Olsson
Keywords	Python programming, GIS, Remote sensing, problem-solving
Hyperlink	https://www.nateko.lu.se/NGEN20

Description

The aim of the course is for students to acquire the knowledge and skills needed to use the Python programming language for solving problems and tasks in geographic information systems (GIS), remote sensing, and applications within physical geography and ecosystem science. The course is primarily practice-oriented, providing training in problem-solving and in structuring problems to be addressed with programming tools. A further overarching goal is to enhance graduates' employability in both the public and private sectors, as well as in research.

Learning outcomes

Knowledge and understanding

On completion of the course, the student shall be able to:

- give an account of the basics of programming and the basic principles of encoding
- describe given problems and how they can be structured to be solved with different relevant programming tools
- explain the importance of programming in the application fields GIS and remote sensing.

Competence and skills

On completion of the course, the student shall be able to:

- master basic technologies for programming in the programming language Python
- apply programming to be able to solve problems in GIS and remote sensing independently
- use programming tools to streamline a workflow
- write own programmes based on commercial and open-source code libraries
- troubleshoot and correct programmes that have been created by others
- document and describe programme code.

Judgement and approach

On completion of the course, the student shall be able to:

- evaluate and assess prescribed applications of programming for given problems
- suggest improvements in existing programme code
- argue for and demonstrate the use with programming practically to solve relevant problems.

Content

The course gives theoretical bases of programming and application of programming in GIS and remote sensing with a focus on practical exercises and applications within physical geography and ecosystem sciences. The course starts with basic programming as handling variables, logical operations, IF clauses and loops, and continues with lists, matrices, file management. Student learn to create their own functions and modules; work with external libraries and object-oriented programming. The final part treats GIS programming with ArcGIS to automate analyses and create their own GIS tools. Apart from the initial programming exercises of basic nature, most cases are based on realistic and relevant GIS and remote sensing applications with connections to physical geography and ecosystem sciences.

Programming for applications in GIS and Remote Sensing

Entry requirements

To be eligible for admission, applicants must have completed at least 90 credits of scientific studies. Within these, a minimum of 15 credits must be in basic Geographic Information Science (GIS) or equivalent such as cartography, geodesy or remote sensing. In addition, applicants must demonstrate proficiency in English equivalent to English 6/English B.

Teaching and learning approach

The teaching consists of compulsory practical exercises to give training in programming and problem-solving. The theory is mostly given in connection with the exercises as a shorter introductory lecture. The course starts with basic programming with gradually increasing difficulty in the exercises and introduces new programming tools with focus on GIS and remote sensing. The final part is completely oriented towards GIS programming and is completed with a programming project that is carried out independently or in groups. All exercises and the final project work are compulsory.

Assessment

Examination takes place in writing in the form of examination and written assignment reports during the course and through a final project work. Students who do not pass an assessment will be offered another opportunity for assessment soon thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

The course consists of the following sub-parts:

- Exam, 5 credits
- Project work, 5 credits
- Python exercises, 5 credit

Geospatial Artificial Intelligence	
Course code	NGEN27
Course type	Compulsory (Track 3 & Track 4)
Period	November 2026 – January 2027
Credits	7.5
Coordinator	Ali Mansourian
Keywords	AI, Machine learning, GIS, Remote sensing
Hyperlink	https://www.nateko.lu.se/NGEN27

Description

The overarching aim of the course is to introduce the student to new paradigms in data management with special focus on artificial intelligence (AI) and machine learning (ML) and their application in GIS and remote sensing.

Learning outcomes

Knowledge and understanding

On completion of the course, the student shall be able to:

- explain differences between knowledge-based and data-driven methods for spatial analysis
- account for how technologies based on artificial intelligence and machine learning methods can be relevant for applications in GIS and remote sensing.

Competence and skills

On completion of the course, the students shall be able to:

- independently use AI for so-called "spatial data mining and knowledge discovery", and thereby process large amounts of spatial data and explore and develop knowledge
- apply AI in spatial simulation and modelling
- apply AI and ML for classification of remote sensing data in the form of satellite images in relevant application fields as e.g. land use mapping.

Judgement and approach

On completion of the course, the students shall be able to:

- critically carry out a literature study reviewing the field of spatial artificial intelligence
- demonstrate a critical and judicious attitude to advanced methods for handling of spatial data in different processes and applications
- evaluate advantages and disadvantages with different AI and ML-methods and be able to relate these to one another at a conceptual level.

Content

The course starts with a general introduction to the concept AI and its different components with a focus on GIS-applications. This is followed by modules with a focus on optimisation of data processing, machine learning and simulation techniques for applications in both GIS and remote sensing. Main focus for the course is technical knowledge and technical proficiencies that are aiming to that the student should be able to apply AI in different situations, but aspects of ethics and public benefits are also treated in lectures during the course.

Entry requirements

To be eligible for admission, applicants must have completed at least 90 credits of scientific studies. Within these, a minimum of 15 credits must be in basic Geographic Information Science (GIS) and 15

Geospatial Artificial Intelligence
credits in programming (equivalent to NGEN20). In addition, applicants must demonstrate proficiency in English equivalent to English 6/English B.
Teaching and learning approach
The teaching consists of lectures, practical exercises, seminars and a final project assignment that is carried out individually or in groups. Each lecture theme is highlighted with practical exercises that, based on key elements, expands and deepens the understanding of the theoretical material. Through the exercises, the student gets ability to apply AI on different spatial problems to develop solutions. Both exercises and seminars aim also to deepen the students' commitment in their own learning process. Participation in exercises, seminars, laboratory sessions and project work, as well as associated parts, is compulsory.
Assessment
Examination takes place in the form of written assignments, exercises, seminars and quizzes during the course and through a final project work. The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability. The course consists of the following sub-parts: ▪ Written assignments, exercises, seminars, 1 credit ▪ Quizzes,1.5 credits ▪ Final project work, 5 credits

Collection and analysis of 3D Geodata	
Course code	NGEN28
Course type	Compulsory (Track 3 & Track 4)
Period	November 2026 – January 2027
Credits	7.5
Coordinator	Per-Ola Olsson
Keywords	3D geodata, GNSS/Laser scanning, Photogrammetry, Point clouds, 3D models
Hyperlink	https://www.nateko.lu.se/NGEN28

Description

The overarching aim of the course is that the student should acquire knowledge and proficiencies to be able to collect and analyse 3D-geodata. The course contains a theoretical introduction to 3D-geodata with a focus on different application fields. During the course the student develops advanced knowledge about several methods to collect geographic 3D data as for instance GNSS/GPS and laser scanning and methods to extract 3D data from images, e.g. photogrammetry and "structure-from-motion". The course also provides practical skills regarding collection, processing and analysis of 3D-geodata.

Learning outcomes

Knowledge and understanding

On completion of the course, the students shall be able to:

- give an account of the basics of 3D-geodata and the need of 3D-geodata in different relevant application fields e.g. physical planning and hydrological modelling
- explain how 3D-geodata can be collected with technologies based on GNSS/GPS, laser scanning, photogrammetry and "structure-from-motion" technologies
- explain differences between different methods for collection of 3D-geodata and describe advantages and disadvantages with different collection methods depending on application
- describe how 3D-geodata can be used for analyses of relevant problems and phenomena.

Competence and skills

On completion of the course, the students shall be able to:

- demonstrate ability to use different technologies to collect and analyse 3D-geodata
- plan and carry out fieldwork for collection of 3D-geodata
- independently use dedicated software for processing of collected 3D-geodata
- extract objects from point clouds
- carry out analyses with 3D-geodata.

Judgement and approach

On completion of the course, the students shall be able to:

- provide arguments for which methods for collection of 3D data that are appropriate for different applications
- Critically assess the quality of different types of collected 3D data.

Content

The course gives a theoretical basis for application of 3D-geodata, e.g. 3D-city models and digital terrain models. The theoretical parts also provide advanced knowledge of different methods for collection of 3D data. Both methods for direct collection of 3D-geodata, GNSS/GPS and laser scanning as methods based on images, photogrammetry and structure-from-motion will be treated. The course

Collection and analysis of 3D Geodata

contains several practical components. Field work is carried out to collect 3D-geodata with GNSS technology, terrestrial laser scanning and image data with unmanned aerial system (UAS). Exercises in computer lab are carried out to process data to create point clouds, orthophotos and 3D models. The course also contains exercises to analyse collected and processed 3D data.

Entry requirements

To be eligible for admission, applicants must have completed at least 90 credits of scientific studies. Within these, a minimum of 15 credits must be in basic Geographic Information Science (GIS) or equivalent such as cartography, geodesy or remote sensing. In addition, applicants must demonstrate proficiency in English equivalent to English 6/English B.

Teaching and learning approach

The teaching consists of lectures and practical components, both in the form of exercises in the field and exercises in a computer lab. The course also contains study visits and guest lectures that give a broader insight in how 3D data can be used in different subject areas. Exercises, study visits, guest lectures and associated components are compulsory.

Assessment

Examination is in the form of a written exam at the end of the course and through written presentations of exercises and a project assignment (2.5 credits) during the course. Students who do not pass the regular exam will have an additional opportunity to re-sit the exam soon thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

The course consists of the following sub-parts:

- Written exam, 5 credits
- Exercises and project ,2.5 credits

Internship	
Course code	NGEA52
Course type	Compulsory (Track 3 & Track 4)
Period	Spring term 2027
Credits	15
Coordinator	Jean-Nicolas Poussart
Keywords	Work experience, Knowledge application, Professional skills
Hyperlink	https://www.nateko.lu.se/NGEA52

Description

The general aim of the course is to provide students with practical work experience in a field relevant to their education, while also offering opportunities to establish connections with potential employers. The internship is designed to bridge theory and practice by enabling students to apply the knowledge acquired during their studies and to gain insight into how companies and public authorities address relevant issues in physical geography and ecosystem science.

Learning outcomes

Knowledge and understanding

On completion of the course, the students shall be able to:

- describe their experiences from work in a relevant field
- give an account of typical duties at a relevant workplace
- describe how work for a physical geographer in a relevant sphere of activity functions and give examples of how the labour market looks like
- give an account of flows in the processes and projects that the internship has involved.

Competence and skills

On completion of the course, the students shall be able to:

- plan an internship and work at a workplace according to a time plan
- demonstrate ability to interact in the context where the internship took place
- apply knowledge and skills from previous studies to communicate professionally orally and in writing with different groups on a workplace
- describe relevant tasks that have been included in the internship in writing
- put their own contribution and their own knowledge in a wider perspective
- demonstrate skills required to work independently in the environmental science area.

Judgement and approach

On completion of the course, the students shall be able to:

- critically evaluate their own contribution to the activities where the internship is carried out
- identify needs of additional knowledge or skills that are needed to meet the requirements of the labour market.

Content

The internship can be at companies, organisations, departments or public authorities where collection, processing, analysis or use of relevant data is carried out in a practical or applied context.

Entry requirements

Admission to the course requires general entry requirements and 75 credits in physical geography and ecosystem science or equivalent.

Internship
Teaching and learning approach
The course is planned and carried out by the student in consultation with the course director and the workplace supervisor. The internship placement, assigned tasks, and designated supervisor must be approved by the course coordinator. A planning document, prepared jointly by the student and the host supervisor, is submitted for approval to the course coordinator. Two weeks after the start of the internship, the student provides a progress report to the coordinator. Upon completion, the student submits a short written report reflecting on experiences and observations. The workplace supervisor also provides a written evaluation confirming whether the student has satisfactorily completed the internship. Internships may take place at companies, public authorities or organisations. Students are expected to participate in daily workplace activities and/or carry out a specific assignment. The internship must comprise at least 40 full-time working days (8 hours per day). For practical reasons, these may be divided across multiple periods or workplaces and may take place outside the regular semester. The internship is arranged by the student but requires prior approval from the course coordinator. Throughout the internship, students are expected to maintain regular contact with both the host supervisor and the course coordinator to ensure mutual exchange of experiences and discussion of relevant issues.
Assessment
The examination consists of a written internship report submitted at the end of the course. The report must be approved by the host supervisor, who also certifies the student's attendance and active participation during the internship period. The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Satellite remote sensing	
Course code	NGEN34
Course type	Elective (Track 3 & Track 4)
Period	March 2027 – June 2027
Credits	15
Coordinator	Lars Eklundh
Keywords	Remote sensing | Vegetation | Optical, Earth
Hyperlink	https://www.nateko.lu.se/ngen34

Description

The overarching aim of the course is that the students should have advanced knowledge and proficiencies in satellite based remote sensing for studies of the environments of the Earth with a focus on optical remote sensing of terrestrial ecosystems.

Learning outcomes

Knowledge and understanding

On completion of the course, the students shall be able to:

- describe the basic physical principles of optical remote sensing including the most common phenomenon and their units
- account for the basic technical principles of satellites, sensors and ground receiving segments of the data collection process and the properties of available data from these systems
- account for the principles of digital image handling and image processing within remote sensing
- give an account of principles of sampling methods, field data collection and accuracy estimation
- account for the principles of change detection and time series analysis within remote sensing
- describe important fields of application for satellite remote sensing in research, public and private enterprise activities
- illustrate and suggest use of remote sensing in different climate regions, for various types of ecosystems and land use systems
- account for limitations with the current technology

Competences and skills

On completion of the course, the students shall be able to:

- analyse digital remote sensing data by means of existing image processing software
- independent and in groups plan and within given time frames carry out studies based on remote sensing data
- apply integrated analysis of satellite data, field data and other data in geographic information systems
- carry out change studies and time series analyses with remote sensing data
- carry out field surveys with data sampling as support for accuracy estimation of maps produced from remote sensing data
- based on literature choose relevant data and methods for applying remote sensing in fields that are related to soil, vegetation, water and the human use of these resources
- present results based on different remote sensing methods in writing, orally and in map form for professionals and the general public
- actively use knowledge from scientific studies to contribute to discussions on practical applications and uses of remote sensing.

Judgement and approach

On completion of the course, the student shall be able to:

Satellite remote sensing

- compile, evaluate and discuss choice of data and analytical method to solve a given problem using remote sensing
- make assessments of the applicability of the remote sensing from a scientific/technical perspective as well as in relation to given societal problems with an emphasis on land use, environment and climate
- reflect on the role of the remote sensing in planning and development activities
- critically review, evaluate and discuss the reliability of analyses that are based on remote sensing data
- discuss ethical aspects of different remote sensing methods and applications.

Content

The course consists of two modules:
1. remote sensing theory and image processing (7.5 credits)
The sub-part treats basic physical principles and terminology for remote sensing and an overview of existing satellites and sensors. Further, data processing and basic image processing methods within remote sensing including radiometric and geometric correction, image enhancement, image classification methods, image transformations, integration of field data and thematic map production, are dealt with.
2. Applications of remote sensing for studies of environment and society (7.5 credits)
This part treats application of satellite based remote sensing in important application fields e.g. vegetation, agriculture, forestry, urban applications, water management, society or climate. Furthermore, use of satellite data is treated in different time and room resolution and analysis of data from different climate regions, is also included in this part of the course. Aspects of importance for the students' professional role within industry and research are integrated in the different components.

Entry requirements

For admission to the course English B/6 and at least 90 credits in scientific studies is required, of which at least 15 credits must be in geographic information science (or equivalent, such as spatial analysis, cartography, geodesy, or remote sensing).

Teaching and learning approach

The teaching consists of lectures, group work, field exercises, seminars and projects. Participation in group work, field exercises, seminars and projects and associated parts, is compulsory.

Assessment

Examination for module 1 is in the form of a written exam during the time of the module. Examination for module 2 is in the form of written assignments and project work during the time of the module. Students who do not pass the regular exam will have an additional opportunity to resit the exam soon thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Geographical Databases	
Course code	NGEN22
Course type	Elective (Track 3 & Track 4)
Period	January 2027 – March 2027
Credits	7.5
Coordinator	Zheng Duan
Keywords	Spatial databases, Object-oriented modelling, SQL, Queries
Hyperlink	https://www.nateko.lu.se/ngen22

Description

The goal of the course is for students to develop a theoretical understanding of how geographic databases are structured and applied. In addition, the course emphasises practical skills, enabling students to model, design, and effectively use geographic databases upon completion.

Learning outcomes

Knowledge and understanding

On completion of the course, the student shall be able to:

- explain how query languages can be used to create an advanced relational database and how it is used for advanced data selection
- describe how geographic data are stored in a searchable way in a database
- analyse advantages and disadvantages to store geographic data in a database compared with to store them in a file structure
- give an account of basic concepts in object-oriented modelling and explain how object-oriented modelling can be used to describe the structure for a geographic database.

Competence and skills

On completion of the course, the student shall be able to:

- independently create an object-oriented model for the structure of a geographic database by means of a standard tool for database modelling
- communicate with a database developed for geographic data

Judgement and approach

On completion of the course, the student shall be able to:

- critically review and compare different structures and storing models for geographic data

Content

The course content includes key concepts for handling geographic databases with special focus on spatial databases, object-oriented modelling of the contents of geographic databases, the query language SQL (and spatial development of this) and indexing of spatial data. The concepts of open-source code for geographic databases and so called "Volunteered Geographic Information" (VGI) are also included in the course.

Entry requirements

Admission to the course requires at least 90 credits in natural sciences or technology of which at least 15 credits should be in Geographic Information Science. In addition, applicants must demonstrate proficiency in English equivalent to English 6/English B.

Teaching and learning approach

The teaching consists of theoretical lectures and practical exercises. The practical exercises are connected to the theoretical concepts and highlight these with data from relevant applications. The course also contains a final compulsory group work project presented in a written report. Participation in exercises and projects and associated components is compulsory.

Assessment

Examination on the course is done by a written exam at the end of the course, via a project work that is presented at the end of the course and exercise submissions during the course. Students who do not pass the regular exam will have an additional opportunity to re-sit the exam soon thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

The course consists of the following sub-parts:

- Exam, 5 credits
- Project work and exercises, 2,5 credits

Spatial Analysis	
Course code	NGEN23
Course type	Elective (Track 3 & Track 4)
Period	January 2027 – March 2027
Credits	7.5
Coordinator	Jonathan Seaquist
Keywords	Geostatistics, Uncertainty and scale, Spatial autocorrelation
Hyperlink	https://www.nateko.lu.se/ngen23

Description

The overarching aim of the course is to provide students with fundamental knowledge and understanding of the principles of spatial analysis in various applications within physical geography. By the end of the course, students will be able to select and apply appropriate analytical methods to address specific spatial analysis problems.

Learning outcomes

Knowledge and understanding

On completion of the course, the student shall be able to:

- explain how and why knowledge in geography is important when analysing spatial data
- describe different methods that are used for the analysis of different types of spatial data
- analyse different types of geographic data by using both descriptive and inferential statistical methods
- give an account of how uncertainty and scale may lead to different limitations and possibilities in analysis of geographic data and what different patterns this could result in.

Competence and skills

On completion of the course, the student shall be able to:

- independently choose relevant spatial analytical methods for different types of geographic data, processes and phenomena
- independently analyse, interpret and criticise result of different spatial analytical methods.

Judgement and approach

On completion of the course, the student shall be able to:

- show a critical approach to spatial analytical methods
- evaluate advantages and disadvantages with different methods for spatial analysis and choose right method for a given practical application and discuss them from a wider context.

Content

The course contains different basic components of spatial analysis, both regarding theoretical background and analytical methods. Some of the concepts and technologies that are treated in the course are point pattern analysis, geo-statistics, spatial autocorrelation, scale, uncertainty and spatial regression. The student also acquires knowledge on how to analyse spatial data by using the open-source platform R.

Entry requirements

Admission to the course requires at least 90 credits in natural sciences or technology of which at least 15 credits should be in Geographic Information Science. In addition, applicants must demonstrate proficiency in English equivalent to English 6/English B. Furthermore, knowledge in basic statistics is required, corresponding to the basic knowledge in statistics that one can be expected to receive during a completed undergraduate education.

Teaching and learning approach

The teaching consists of both theoretical and practical components where lectures are followed by practical exercises that illustrate, reinforce or develop the theoretical concepts that are brought up in the lectures. The emphasis lies on statistical analysis and interpretation of the results. The exercises are often cumulative, i.e. the knowledge that is received in an exercise is used as introduction to tackle the problem that is set up in the next exercise. Participation in exercises is compulsory.

Assessment

Examination takes place in the form of a written exam at the end of the course and through different written assignments during the course. Students who do not pass the regular exam will have an additional opportunity to re-sit the exam soon thereafter.

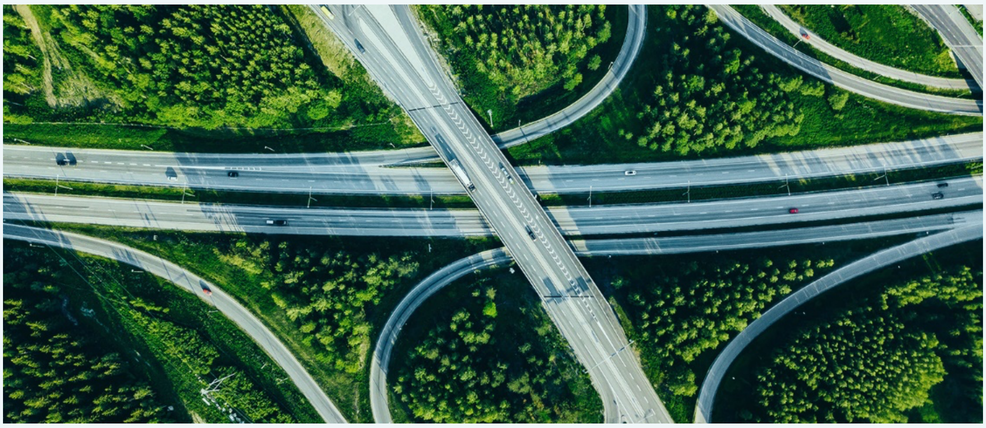
The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

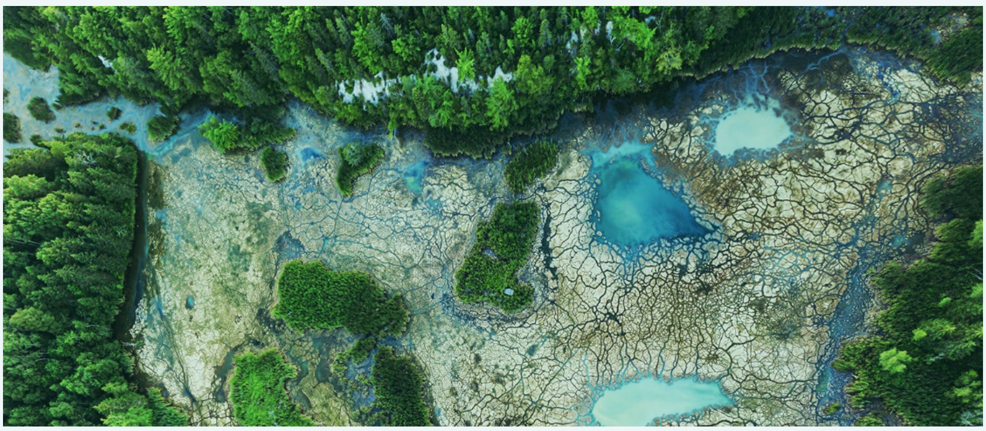
The course consists of the following sub-parts:

- Exam, 5 credits
- Written hand-ins (exercises), 2,5 credits

Courses in year 2 at ITC-University of Twente, the Netherlands

Track 1 – Geospatial Planner | Track 3 – Geospatial Developer





MSc research proposal writing [under revision]	
Course code	202500080
Course type	Compulsory (Track 1 & Track 3)
Period	September 2027 – November 2027
Credits	5 EC
Coordinator	Pinto Soares Madureira
Keywords	MSc proposal
Hyperlink	Link to the OSIRIS course description

Description

The first stage of this course is spent on developing an MSc Research Proposal with support and feedback from staff and peers. Through the MSc Research Proposal, the students should demonstrate the ability to undertake independent research. At the end of the first quartile the MSc Research Proposal will be assessed by a Proposal Assessment Board based on a written proposal, a presentation and an oral defence. The Proposal Assessment Board decides if the proposal is acceptable, as one of the conditions to continue with the MSc Research phase.
The second stage of the course is dedicated to the execution of an individual research project. Each student works independently on the basis of an approved research proposal.
In this final part of the course, the students further develop their research skills, interact with their fellow students, PhD researchers and staff members and, finally, demonstrate that they have achieved the learning outcomes of the Master's programme by research, on a satisfactory academic level.

Learning outcomes

1. Address a well-formulated relevant research problem of sufficient scope and depth related to the application of geo-information and earth observation and linked to relevant literature (scientific scope and depth)
2. Undertake research with a clear and transparent methodology with proper use of concepts, methods and techniques (scientific method)
3. Write a well-structured and readable thesis report with a clear layout (reporting)
4. Orally present and defend the research and use proper argumentation in the discussion about the research (presentation and defence)
5. Work in a structured and independent way, while making adequate use of the guidance of the supervisor (process)
6. Reflect and discuss in the thesis, the relevance of the research in different cultural and international contexts, or present the research in an international setup, through reflecting on its utility in overarching cultural and societal differences and fostering of stakeholder partnerships.

Content

Guided Proposal Writing
Introductory lectures on:
- MSc Research phase process Research ethics

Tutorials and peer discussion on:
- Formulating sub-objectives and research questions Methodology
- Ethical considerations in MSc research Optional, theme-specific tutorials
- Data collection methods Data analysis methods

Proposal defence
- Oral presentation and defence of the MSc research proposal before the Proposal Assessment Board

Thesis Writing

MSc research proposal writing [under revision]		
▪ Based on the accepted research proposal the student will carry out the planned activities. Regular individual progress meetings with the supervisors will be held to facilitate the progress on the research and thesis writing, and records of the progress will be kept. The activities include: ▪ Deepen literature review, including assessment of the usability of literature and previous research; Collection of relevant data. If appropriate, preparation and execution of fieldwork to collect primary data required for the research; ▪ Data processing and analysis ▪ Active participation in seminars and activities of the research theme under which the MSc research resorts; ▪ Mid-term presentation: A formative assessment is made on the research progress approximately half- way the thesis development time-frame ▪ Preparation of the final manuscript of the MSc thesis ▪ A critical review of the quality, use, and usefulness of the data and results, as well as the learning process ▪ Oral presentation and defence of the MSc thesis before the Thesis Assessment Board.		
Entry requirements		
Students should have at least 60 credits of the first year. Supervised MSc thesis writing can only start after a successful MSc proposal defence.		
Teaching and learning approach		
Students are assigned a supervisor or team of supervisors to guide them during their individual research. Students will make individual arrangements with their supervisor(s) regarding the frequency of supervision meetings and the extent of the guidance they can expect.		
Time allocation in hours per activity		
Lecture [contact]	4	
Supervised practical [contact]	12	
Tutorial [contact]	12	
Written/oral test	4	
Self-study	1228	
Sum	**1260**	
Assessment		
Examiners	ITC (and Tartu/Lund) staff	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Proposal assessment	n/a	individual
Thesis defence	100	individual

MSc research and thesis writing [under revision]	
Course code	202500080
Course type	Compulsory (Track 1 & Track 3)
Period	November 2027 – July 2028
Credits	35 EC
Coordinator	Pinto Soares Madureira
Keywords	MSc research | MSc thesis
Hyperlink	Link to the OSIRIS course description

Description

The first stage of this course is spent on developing an MSc Research Proposal with support and feedback from staff and peers. Through the MSc Research Proposal, the students should demonstrate the ability to undertake independent research. At the end of the first quartile the MSc Research Proposal will be assessed by a Proposal Assessment Board based on a written proposal, a presentation and an oral defence. The Proposal Assessment Board decides if the proposal is acceptable, as one of the conditions to continue with the MSc Research phase.
The second stage of the course is dedicated to the execution of an individual research project. Each student works independently on the basis of an approved research proposal.
In this final part of the course, the students further develop their research skills, interact with their fellow students, PhD researchers and staff members and, finally, demonstrate that they have achieved the learning outcomes of the Master's programme by research, on a satisfactory academic level.

Learning outcomes

1. Address a well-formulated relevant research problem of sufficient scope and depth related to the application of geo-information and earth observation and linked to relevant literature (scientific scope and depth)
2. Undertake research with a clear and transparent methodology with proper use of concepts, methods and techniques (scientific method)
3. Write a well-structured and readable thesis report with a clear layout (reporting)
4. Orally present and defend the research and use proper argumentation in the discussion about the research (presentation and defence)
5. Work in a structured and independent way, while making adequate use of the guidance of the supervisor (process)
6. Reflect and discuss in the thesis, the relevance of the research in different cultural and international contexts, or present the research in an international setup, through reflecting on its utility in overarching cultural and societal differences and fostering of stakeholder partnerships.

Content

Guided Proposal Writing
Introductory lectures on:
- MSc Research phase process Research ethics

Tutorials and peer discussion on:
- Formulating sub-objectives and research questions Methodology
- Ethical considerations in MSc research Optional, theme-specific tutorials
- Data collection methods Data analysis methods

Proposal defence
- Oral presentation and defence of the MSc research proposal before the Proposal Assessment Board

Thesis Writing

MSc research and thesis writing [under revision]		
▪ Based on the accepted research proposal the student will carry out the planned activities. Regular individual progress meetings with the supervisors will be held to facilitate the progress on the research and thesis writing, and records of the progress will be kept. The activities include: ▪ Deepen literature review, including assessment of the usability of literature and previous research; Collection of relevant data. If appropriate, preparation and execution of fieldwork to collect primary data required for the research; ▪ Data processing and analysis ▪ Active participation in seminars and activities of the research theme under which the MSc research resorts; ▪ Mid-term presentation: A formative assessment is made on the research progress approximately half- way the thesis development time-frame ▪ Preparation of the final manuscript of the MSc thesis ▪ A critical review of the quality, use, and usefulness of the data and results, as well as the learning process ▪ Oral presentation and defence of the MSc thesis before the Thesis Assessment Board.		
Entry requirements		
Students should have at least 60 credits of the first year. Supervised MSc thesis writing can only start after a successful MSc proposal defence.		
Teaching and learning approach		
Students are assigned a supervisor or team of supervisors to guide them during their individual research. Students will make individual arrangements with their supervisor(s) regarding the frequency of supervision meetings and the extent of the guidance they can expect.		
Time allocation in hours per activity		
Lecture [contact]	4	
Supervised practical [contact]	12	
Tutorial [contact]	12	
Written/oral test	4	
Self-study	1228	
Sum	**1260**	
Assessment		
Examiners	ITC (and Tartu/Lund) staff	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Proposal assessment	n/a	individual
Thesis defence	100	individual

Advanced Professional & Scientific Skills [in development]		
Course code	Not available yet	
Course type	Compulsory (Track 1 & Track 3)	
Period	November 2027 – July 2028	
Credits	5 EC	
Coordinator	Marloes Penning de Vries	
Keywords	Project management | collaboration | Peer review | Academic publishing | Entrepreneurship | Communication & outreach	
Hyperlink	Not available yet	
Description		
The Professional Skills Development courses are electives. The transferable skills aim to prepare students for a future academic (A) or other (O) career (e.g., industry, agencies, government, etc.), but do not depend on each other. Students **must** choose a minimum of 5 EC (== 2 courses of 2.5 EC each). Courses to select from are: ▪ •Project management & collaboration (A) ▪ •Peer review & academic publishing (A) ▪ •Introduction to entrepreneurship (O) ▪ •Communication & outreach (O)		
Learning outcomes		
in development		
Content		
in development		
Entry requirements		
#		
Teaching and learning approach		
#		
Time allocation in hours per activity		
Lecture [contact]	#	
Supervised practical [contact]	#	
Tutorial [contact]	#	
Written/oral test	#	
Self-study	#	
Sum	**#**	
Assessment		
Examiners	ITC staff	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
#	#	individual
#	#	individual

Spatial analyses of ecosystem services: nature's benefits to people	
Course code	201900057
Course type	Elective (Track 1)
Period	February 2028 – April 2028
Credits	5 EC
Coordinator	Nina Schwartz | Louise Willemen
Keywords	Social-ecological systems | Geo-information | Sustainability | Planning | Resource management
Hyperlink	Link to the OSIRIS course description

Description

Ecosystem services i.e., the contributions of nature to human well-being, are increasingly used to describe human-nature interactions in an inclusive way. The ecosystem services concept addresses management objectives that go beyond natural resources or human practices alone, as it focuses on the interactions between nature and society. Geo-information is inherent to ecosystem service assessments, since the supply (from ecosystems) and demand (from society) for ecosystem services are spatially explicit. Understanding the ecosystem service concept, selecting and using mapping methods for specific management objectives is therefore essential for incorporating human-nature interactions into environmental management and hence the key objective of this course. Managing natural resources in a sustainable way by taking into account human well-being is also at the core of the Sustainable Development Goals as set by the United Nations. After completing this course, the student will have obtained knowledge in the theoretical aspects of ecosystem services and the definitions, classification systems. The student will also be able to select and apply mapping methods for ecosystem service assessments on real-life applications in the context of diverse management objectives.

Learning outcomes

Upon completion of this course, the student is able to:

- Summarise the history, explain the definitions and types of classification of ecosystem services.
- Distinguish ecosystem service supply, use, demand and value.
- Interpret ecosystem service information for diverse decision-making objectives in three different systems (urban, rural and marine).
- Use data and tools for ecosystem service mapping for one case study application
- Evaluate and select tools for ecosystem service mapping for selected decision-making objectives.
- Formulate opportunities and challenges of geo-information on ecosystem services for resource management and planning.

Content

Knowledge, methods, skills, approaches that the students will learn:

- Human-nature relations: Scientific concepts over time, terminology of ecosystem services, Natural Capital, Nature-based Solutions, Green/Blue Infrastructure
- Ecosystem service classifications
- Concepts of ecosystem service supply, use, demand, and value
- Decision making frameworks: phases and (geo-) information needs
- Decision making & mapping challenges: in urban, rural and marine systems
- ES quantification and valuation approaches: social, economic and ecological measures, interactions, relevance.
- Ecosystem service mapping methods/tools/software: based on GIS, Remote Sensing, Participatory GIS, and analysis of the results
- Ecosystem service data: requirements, sources, challenges
- Comparing and contrasting ecosystem service mapping methods for decision making challenges

Spatial analyses of ecosystem services: nature’s benefits to people		
Entry requirements		
Able to independently use GIS software; strong interest in interdisciplinary work		
Teaching and learning approach		
(guest) lectures, computer practicals, practice professional implementation of course topic, self-study includes reading and exercises , plenary discussions.		
Time allocation in hours per activity		
Lecture [contact]	20	
Supervised practical [contact]	18	
Tutorial [contact]	11	
Study trip [contact]	4	
Written/oral test	2	
Individual assignment	0	
Group assignment	43	
Self-study	42	
Sum	140	
Assessment		
Examiners	Nina Schwarz, Louise Willemen	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Individual assignment	50	individual
Group assignment	50	group

Environmental assessment using SDSS and advanced EO tools [under revision]	
Course code	201900045
Course type	Elective (Track 1)
Period	February 2028 - April 2028
Credits	5 EC
Coordinator	Elnaz Neinavaz
Keywords	Environmental assessment | spatial decision support | EO | planning
Hyperlink	Add hyperlink

Description

How can spatial decision support (SDS) and advanced earth observation tools enhance the environmental assessment process to ensure sustainable planning and decision-making?

Ad hoc and often uncontrolled development initiatives can have undesired social, economic and ecological consequences. Rapid population growth, pollution, climate change, exposure to hazards and disasters, and the loss of biodiversity and ecosystem services require effective assessment tools to assist sustainable planning and decision-making.

Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) are the basic procedures to support this process. The key principles of EIA and SEA are the involvement of relevant stakeholders, a transparent and adaptive planning process, consideration of alternatives, and using the best possible information for decision and policymaking. They, therefore improve both the (spatial) planning process and the information used in this process. In addition, earth observation (EO) tools can provide the biophysical baseline occurring in a given geographical area and be used in monitoring of the proposed activity, making the environmental assessment process more efficient.

In this course, you will not only explore how SEA can be integrated in the planning process to enhance sustainable decision-making, but also will address how GIS, spatial decision support and advanced EO tools such as unmanned aerial vehicle (UAV) and high-resolution space-borne imagery, can be used to help identify and structure the problem(s), as well as generate and compare possible solutions, and monitor and evaluate the proposed activities.

Hands-on experience with real EIA and SEA projects will be a major part of the course.

Learning outcomes

- Explain the basic principles, procedures and steps in EIA & SEA and their integration in the planning process.
- Analyze the potential application of GIS and advanced EO tools in the environmental assessment process
- Incorporate hazard, vulnerability and risk in EA for (spatial) planning
- Apply SDS tools to define, analyse and assess alternatives
- Carry out an EA project dealing with a typical application within the field of SEA & EIA for spatial planning
- Evaluate the use of GIS, EO and SDS tools in EA

Content

The course exists of eight modules and includes the following topics:

- Introduction and EIA
- SEA: concepts, principles, stages and interaction with the planning process
- Advanced EO tools: review of UAV and high-resolution space-borne imagery principals, applications in environmental assessments and their advantages
- Screening & Scoping: key elements & plan objectives, key issues, SEA objectives and identification of alternatives & options

Environmental assessment using SDSS and advanced EO tools [under revision]		
▪ Assessment: baseline information, impact prediction & significance, mitigation, comparison of alternatives and justification for selected one(s); SEA report ▪ Spatial Decision Support tools in EA: spatial multi-criteria evaluation for site selection and vulnerability analysis ▪ Review and decision-making ▪ Monitoring ▪ Final project dealing with a typical application within the field of environmental assessment for spatial planning		
Entry requirements		
▪ GIS and Remote Sensing skills ▪ Basic understanding of environmental issues		
Teaching and learning approach		
The course will be 'problem-driven', based on learning by doing. Several real-life based case studies from different disciplines will be offered to gain hands-on experience in environmental assessment for sustainable planning and decision-making. Teaching will be based on presentations, supervised and un-supervised practical, self-study, plenary discussions, self-tests; project work.		
Time allocation in hours per activity		
Lecture [contact]	26	
Supervised practical [contact]	26	
Tutorial [contact]	6	
Study trip [contact]	0	
Written/oral test	0	
Individual assignment	32	
Group assignment	20	
Self-study	30	
Sum	140	
Assessment		
Examiners	Elnaz Neinavaz	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Assignment in Advantages and disadvantages of the use of SDS tools in EA	10	individual
Assignment in Monitoring with EO	10	individual
Assignment Visual identification of tree species from UAV imagery	10	individual
Assignment in GIS in EA	10	individual
Summary report	60	group

Digital Participatory Planning: Planning Support Systems for Decision Rooms, Web Applications, and Serious Games [under revision]		
Course code	Not available yet	
Course type	Elective (Track 1)	
Period	November 2028 - February 2028	
Credits	5 EC	
Coordinator	Luc Boerboom	
Keywords	Not available yet	
Hyperlink	Not available yet	
Description		
No description available yet		
Learning outcomes		
No description available yet		
Content		
▪ No description available yet		
Entry requirements		
#		
Teaching and learning approach		
#.		
Time allocation in hours per activity		
Lecture [contact]	#	
Supervised practical [contact]	#	
Tutorial [contact]	#	
Study trip [contact]	#	
Written/oral test	#	
Individual assignment	#	
Group assignment	#	
Self-study	#	
Sum	#	
Assessment		
Examiners	Elnaz Neinavaz	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
#	#	individual
#	#	group

Quantitative Remote Sensing of Vegetation Parameters	
Course code	201900062
Course type	Elective (Track 3)
Period	November 2027 - February 2028
Credits	5
Coordinator	Roshanak Darvishzadeh
Keywords	Vegetation traits | phenology | empirical models | time-series images | radiative transfer model
Hyperlink	Link to the OSIRIS course description

Description

This course is about the retrieval of quantitative information on vegetation. In particular, the focus will be on vegetation traits, namely leaf area index and phenology and how they can be estimated using remote sensing.
Definitions and details about these parameters, how they are measured in the field, and how they are estimated using remote sensing data will be provided during the course.

Learning outcomes

1. Upon completion of this course, the student will be able to:
2. To explain the spectral properties of vegetation and explain the use and role of vegetation parameters in various applications for terrestrial ecosystems
3. To conduct field and laboratory measurements for several pant traits
4. To describe modelling approaches of plant traits, including general statistical approaches (such as calculation of various vegetation indices), and simple radiative transfer models.
5. To explain existing phenological analysis techniques and its relevance to a range of applications.
6. To estimate phenological parameters, such as start- and end-of-season, from satellite image time series
7. To apply the learned techniques in an individual assignment related to the student's MSc thesis

Content

- Introduction to biophysical and biochemical parameters
- Measurements of leaf area index (LAI)
- Field and laboratory measurements
- Spectral properties of leaves, canopies and soil
- Lab spectroscopy
- Statiscal methods (Vegetation indices, Red edge inflection Point, Multivariate methods)
- leaf and canopy radiative transfer models and their inversion.
- introduction to phenology and its applications for studing ecosystems, agriculture, and climate
- retrieval phenology from coarse-resolution remote sensing time series
- retrieval of phenology at fine spatial detail from Sentinel-2
- validation: linking phenological retrievals to field data, including from digital repeat cameras

Entry requirements

GIS and remote sensing skills

Teaching and learning approach

A series of lectures, tutorials in the forms of discussions and Q&A sessions, supervised practical, use of online materials, field and lab tutoring will be implemented.

Time allocation in hours per activity

Lecture [contact]	26
Supervised practical [contact]	35

Quantitative Remote Sensing of Vegetation Parameters		
Tutorial [contact]	18	
Study trip [contact]	7	
Written/oral test	4	
Individual assignment	24	
Group assignment	7	
Self-study	19	
Sum	**140**	
Assessment		
Examiners	Anton Vrieling, Roshanak Darvishzadeh	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills in measurements of biophysical parameters	20	group
Practical skills in Phenology	20	group
Individual report and presentation	60	individual

Environmental Monitoring with Integrated EO Data Image and Time Series	
Course code	202500083
Course type	Elective (Track 3)
Period	February 2028 - April 2028
Credits	5
Coordinator	Margarita Huesca-Martinez
Keywords	#
Hyperlink	Link to the OSIRIS course description

Description

The 21st century has witnessed an increase in the availability and use of satellite images to capture changes in landscape patterns through time. You may have already been exposed to classical change detection analysis, which is a type of monitoring in which changes in landscape patterns are quantified from satellite imagery between two snapshots in time. Change detection analysis in this way is insufficient however when the processes under investigation are highly dynamic, e.g. agricultural droughts, ecosystem "tipping points" and forest fires. Such cases require continuous monitoring of satellite images at daily, bimonthly or monthly intervals with time series analysis (TSA). Continuous satellite image data, referred to as Satellite Image Time Series (SITS) in this course, are used to monitor highly dynamic processes. Ecological indicators derived from SITS capture landscape patterns consistently at frequent intervals, which enable researchers and natural resource managers to detect both abrupt changes and slow trends over time. In addition, SITS spanning long periods of time, provide insights into the "drivers of change" and underlying mechanisms governing change. Several satellite image archives are now publicly available with the emergence of relatively inexpensive high-performance cloud computing platforms. Each archive presents unique challenges in terms of acquisition and processing. At the same time, TSA encompasses an array of quantitative approaches to monitor and forecast ecological indicators derived from SITS. These include among others, autoregressive (AR), moving average (MA) and autoregressive moving average (ARMA) models.
The number of SITS and methods for TSA can make environmental monitoring with remote sensing a daunting task. The overall goal of this course therefore is to provide you with sufficient knowledge and tools to acquire and process SITS, perform TSA on ecological indicators derived from SITS and design a successful environmental monitoring project. In the NRM Specialization Earth Observation for Natural Resources Management, students are asked to follow the Phinn et al. (2003) procedure when selecting and using a single satellite image and analytical technique to address specific problems in natural resources management (Figure 1). In this course, we shift attention away from early steps of the procedure (scale of observation and general analytical approaches) to latter steps of the procedure (data acquisition, processing, analysis and evaluation). These steps are detailed in Kennedy et al. (2009) for scientists and natural resource managers interested in integrating SITS into their environmental monitoring project.

Learning outcomes

Upon completion of this course, the student will be able to:

1. Deconstruct SITS based on trend, seasonality, cyclical irregularity and structural changes using the BFAST algorithm
2. Model and predict ecological indicators with SITS using the Box–Jenkins method for TSA
3. Detect agricultural droughts, ecosystem tipping points and forest fire activity with SITS
4. Design and implement an environmental monitoring project that acquires, processes, analyzes and evaluates SITS

Content

Environmental Monitoring with Integrated EO Data Image and Time Series		
▪ Key terms and concepts in remote sensing and environmental monitoring ▪ Ecological indicators derived from SITS ▪ SITS: data acquisition and processing ▪ Time series decomposition ▪ Box–Jenkins method for TSA ▪ Detecting agricultural droughts with remote sensing-based evapotranspiration indices ▪ Detecting ecosystem tipping points with spectral vegetation indices ▪ Modeling and forecasting forest fire risk behavior with AR models ▪ Environmental monitoring group project		
Entry requirements		
Basic statistics GIS and RS experience (ILWIS and/or ArcMap, Erdas) Ecological background		
Teaching and learning approach		
The course takes a student-centred (inquiry-based) approach to teaching and learning. Students assume an active/participatory role in their education, while teachers are facilitators who encourage interaction with new material presented and reflective thinking. The teacher uses class discussions, hands-on practicals and other experiential learning tools to track student comprehension, learning needs and academic progress over a teaching unit. Four summative assessments (writing assignment×2 + written exam + final group project) measure how well the students achieve higher order thinking and learning outcomes.		
Time allocation in hours per activity		
Lecture [contact]	16	
Supervised practical [contact]	31	
Tutorial [contact]	7	
Written/oral test	6	
Individual assignment	14	
Group assignment	36	
Self-study	30	
Sum	**140**	
Assessment		
Examiners	Michael Marshall, Margarita Huesca-Martinez	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written assignment	30	Individual
Written test	30	Individual
Oral examination	40	Small groups

Water and Carbon Dynamics in Ecosystems	
Course code	202500081
Course type	Elective (Track 3)
Period	November 2027 - February 2028
Credits	5
Coordinator	Egor Prikaziuk
Keywords	#
Hyperlink	Link to the OSIRIS course description

Description

How do forests, fields, and rivers breathe, drink, and respond to our changing climate? This course puts you at the heart of that question. By combining **satellite data, on-the-ground measurements, and advanced modeling**, you will learn how to monitor ecosystems and track how energy, water, and carbon cycles are intertwined.

With today's explosion of **open-access satellite data and cloud-based computing**, the world is full of opportunities—but only for those who can turn raw data into insight. In this course, you'll gain **hands-on experience in Python** to work with massive datasets on radiation, water, and biogeochemistry. You'll move from downloading satellite imagery to **unlocking stories about ecosystems** that matter for food, water, and climate resilience—critical issues in the Global South and beyond.

A special focus will be on **water use efficiency** at different scales—an urgent theme in regions where every drop counts.

To bridge data with reality, we'll take you out of the classroom into one of ITC's **in-situ monitoring sites (Speulderbos forest)**, where satellites meet the soil and sensors reveal what's happening beneath the canopy.

By the end, you won't just understand ecosystems—you'll have the **skills to shape solutions** for agriculture, climate adaptation, and environmental management at global and local scales.

Watch the video of your instructor teacher https://youtu.be/2it4FY7UrkI?si=SUehUEgayPgRAlh5

Learning outcomes

After completing this course you will be able to:

1. Name remote sensing datasets relevant for computations of radiation, energy, water and carbon budgets
2. Explain the connection between environmental variables and biogeochemical and energy fluxes
3. Compute water balance of a river catchment
4. Compute carbon balance of a terrestrial ecosystem
5. Use CMIP6 dataset to quantify the future effect of climate change on biogeochemical cycles, radiation and energy budgets

Content

Module consists of the study units

- Introduction to global cycles
- Radiation budget
- Energy balance
- Water balance
- Carbon balance
- Field trip

Water and Carbon Dynamics in Ecosystems		
▪ Biogeochemical cycles ▪ Forest water balance ▪ Climate projections ▪ Exam		
Entry requirements		
Understanding of remote sensing techniques and data. Basic programming skills, preferably some experience with Python and Jupyter notebooks.		
Teaching and learning approach		
Not available yet		
Time allocation in hours per activity		
Lecture [contact]	#	
Supervised practical [contact]	#	
Tutorial [contact]	#	
Written/oral test	#	
Individual assignment	#	
Group assignment	#	
Self-study	#	
Sum	**#**	
Assessment		
Examiners	Michael Marshall, Margarita Huesca-Martinez	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Assignment Compute carbon balance of a terrestrial ecosystem	20	Individual
Assignment Compute water balance of a river catchment	20	Individual
Assignment Use CMIP6 dataset to quantify the future effect of climate change	20	Individual
Written exam	40	Individual

Courses in year 2 at Université catholique de Louvain, Belgium

Track 2 – Geospatial Analyst | Track 4 – Geospatial Modeller

Master Thesis	
Course code	LBIRE2200
Course type	Compulsory (Track 2 & Track 4)
Period	September 2027 –May 2028
Credits	27
Coordinator	Depending on the subject
Keywords	Research | work | presentation
Hyperlink	https://uclouvain.be/en-cours-2025-LBIRE2200

Description

The master thesis is a personal work that each student must complete during his master cycle. This thesis is an initiation to scientific research that allows the student to study a topic of his own preference.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of the master thesis, the student is able to:

- Analyse scientific publications that are related to his master thesis topic, master and discuss the corresponding content and present this content in a summarized way;
- design a consistent and sound approach in order to answer a scientific question by using a state-of-the-art knowledge about the question;
- set up an experimental protocol (in a wide meaning of the term), analyse and interpret the corresponding results by the light of the scientific literature at hand and by taking into account the corresponding limitations;
- communicate the results and justify them using a rigorous scientific language, both in a printed document and during a public oral presentation in front of a jury.

Content

The student must identify and address a specific question by respecting the following general approach:

- Summarize the current knowledge about the chosen topic;
- Set an experimental protocol (in a wide meaning of the term);
- Do observations (in the field or in a laboratory);
- Analyse and interpret these observations;
- Draw appropriate conclusions;
- Present this material in a scientific document;
- Publicly defend their work

Entry requirements

Teaching and learning approach

Master Thesis		
The master thesis supervision is under the responsibility of a promoter (possible two co-promoters). The (co)promoter(s) is in charge of supervising the quality and the timing of the work that must be done by the student. These aspects are evaluated as a specific item, i.e. the 'Evaluation of the personal work made by the student', which is part of the final score. It is advised that students choose both the topic and the promoter for their master thesis during the second semester of the first year in the master cycle.		
Time allocation in hours per activity		
Lecture [contact]		
Supervised practical [contact]		
Tutorial [contact]		
Study trip [contact]		
Written/oral test		
Individual assignment		
Group assignment		
Self-study		
Sum		
Assessment		
The work that has been made by the student during the year and in the framework of the master thesis will be evaluated by the promoter (possibly co-promoters) of the master thesis. A jury evaluates bot the quality for the printed document, for the oral presentation and for the public defense.		
Examiners	Depending on the subject	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Work during the year	30	Individual
Printed Document	50	Individual
Public Defense	20	Individual

Master thesis' accompanying seminar	
Course code	LBIRE2210
Course type	Compulsory (Track 2 & Track 4)
Period	September 2027 – May 2028
Credits	3
Coordinator	Patrick Bogaert
Keywords	Research | work | presentation
Hyperlink	https://uclouvain.be/en-cours-2025-lbire2210

Description

The master thesis is an initiation to research work. It is a personal approach that, under the guidance of a teacher, develops the capacity to master experimental approaches, to interpret results on the basis of state-of-the-art knowledge and to identify the perspectives of future investigations. In addition to this methodology, the student should be able to communicate clearly and orally the results of his work. He should also keep a critical mind on the correspondence between the followed approach and the pursued objectives.

In order to make them more visible, these communication activities and critical analysis exercises are valorised through seminars focused on the educational aspects of scientific communication. English must be used for the communication.

Learning outcomes

- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of this activity, the student is able to:

- master computer tools to prepare and present slideshows, as well as tools to prepare scientific graphics ;
- present in English the context and state-of-the-art in the field of his work by defining the objectives and the followed methodology and /or experimental approach ;
- present orally and in English the results that were obtained and the scientific interpretations that can be made from them, both to peers and experts in the field of bioengineering ;
- identify the main achievements of his work and the prospects for future developments;
- answer to open questions and justify his claims in a scientifically rigorous, balanced and critical way.

Content

In a coordinated manner, the master thesis promoters and the head of the programme committee take the initiative to bring together all the students registered for the master thesis. A first meeting during the first semester allows each student to present, in the form of a seminar of around fifteen minutes, the objective of their master thesis, the state of knowledge, the work program and the difficulties encountered. A second meeting during the 2nd semester aims to present, in the form of a seminar of around fifteen minutes, the objectives of the work, a summary of the research results and their discussions as well as the difficulties encountered. These meetings are followed by a discussion of the strengths and weaknesses of the oral presentation, the progress of the work, the proper maintenance of the research calendar and the student's critical thinking.

The seminar presentations are organized in sessions based on the themes and the promoters. The master thesis promoters and the head of the program committee will ensure that all students complete their two seminars. Students are required to attend a minimum number of other seminars by prioritizing topics close to their own theme, according to the terms and conditions communicated to them during the year. Students whose main promoter is not part of the Faculty will be responsible for organizing the seminars themselves, either in agreement with one of the Faculty's laboratories, or in the

Master thesis' accompanying seminar		
laboratory where they carry out their research. In the latter case, the promoter must confirm in writing that the student has completed both seminars		
Entry requirements		
Teaching and learning approach		
Time allocation in hours per activity		
Lecture [contact]		
Supervised practical [contact]	10	
Tutorial [contact]		
Study trip [contact]		
Written/oral test		
Individual assignment		
Group assignment		
Self-study		
Sum		
Assessment		
The oral presentation presented at the public defense of the dissertation is the final outcome of the seminars given during the academic year. The note for this course corresponds to the evaluation of the oral presentation of the dissertation by the jury. This evaluation will focus on 2 points, with equivalent weights: (i) clarity of the presentation (quality of the slideshow, voice modulation, time allocation between the different parts of the presentation, keeping the public attention, etc.) and (ii) scientific rigor of the presentation (terminology, slide content, synthetic capacity, etc.). This rule applies to all students, including those whose promoter is not a teacher of the Faculty. The master thesis promoters and the head of the program committee verify that all students have actually presented both seminars. Any student who do not meet the requirements of this course may be sanctioned (0/20) whatever the quality of the oral presentation during the master thesis defense.		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Public Defense	100	Individual

Smart Technologies for environmental engineering (3 ECTS)	
Course code	LBRES2101B
Course type	Compulsory (Track 2)
Period	September 2027 – December 2027
Credits	3
Coordinator	Sébastien Lambot
Keywords	Technology
Hyperlink	https://uclouvain.be/en-cours-2025-lbres2101B

Description

This course aims to teach technologies for characterization and monitoring of agroecosystems. In particular, geophysical imaging and characterization techniques of soil properties are presented, such as ground penetrating radar, electromagnetic induction or electrical tomography. Also, the course discusses the use of drones for environmental monitoring, including multispectral, thermal infrared, LiDAR sensors as well as photogrammetry. Fundamental concepts, instruments and methods of signal analysis will be particularly seen in-depth. The student will be made familiar with these tools through practical works and an integrated project.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
  - Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach.

At the end of this course, students will be able to:
- understand the concepts of the different environmental sensors (geophysics, remote sensing);
- understand and implement different signal processing methods;
- develop a critical analysis on the application of these technologies;
- to master the use of some of the instruments studied.

Content

Smart Technologies for environmental engineering (3 ECTS)		
Theorical class: ▪ Geophysical techniques: ground penetrating radar, electromagnetic induction, radiometry, electrical tomography, seismic, reflectometry. ▪ Drone remote sensing techniques: thermal infrared sensor, multispectral sensor, LiDAR. ▪ Sensor networks **Practical work:** The main concepts presented during the courses will be applied during practical work sessions (operational mastery) and an integrated project carried out by group. **Seminars:** Students analyze, synthesize and present a scientific article dealing with a scientific question relating to environmental monitoring.		
Entry requirements		
Applied Geomatics; Soil Physics		
Teaching and learning approach		
▪ Lectures ▪ Team-based practical work with an integrated project involving the creation of a collective report. ▪ Seminars aimed at delving into a scientific question related to the course and developing professional communication skills.		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	15	
Sum	**37.5**	
Assessment		
Examiners	Sébastien Lambot	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written Exam	60 (if written exam passed (>10/20), otherwise 100)	Individual
Project Report	20 (if written exam passed (>10/20), otherwise 0)	Group
Seminar	20 (if written exam passed (>10/20), otherwise 0)	Group

Smart Technologies for environmental engineering (3 + 1 ECTS)	
Course code	LBRES2101
Course type	Compulsory (Track 4) – Elective (Track 2)
Period	September 2027 – December 2027
Credits	3 + 1
Coordinator	Sébastien Lambot
Keywords	Technology
Hyperlink	https://uclouvain.be/en-cours-2025-lbres2101

Description

This course aims to teach technologies for characterization and monitoring of agroecosystems. In particular, geophysical imaging and characterization techniques of soil properties are presented, such as ground penetrating radar, electromagnetic induction or electrical tomography. Also, the course discusses the use of drones for environmental monitoring, including multispectral, thermal infrared, LiDAR sensors as well as photogrammetry. Fundamental concepts, instruments and methods of signal analysis will be particularly seen in-depth. The student will be made familiar with these tools through practical works and an integrated project.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach.

At the end of this course, students will be able to:
- understand the concepts of the different environmental sensors (geophysics, remote sensing);
- understand and implement different signal processing methods;
- develop a critical analysis on the application of these technologies;
- to master the use of some of the instruments studied.

Content

Note: LBRES2101 Course (4 credits) constitutes the complete course. LBRES2101B Section (3 credits) excludes the part concerning environmental sensors and topographic tools.

Course Content:

Smart Technologies for environmental engineering (3 + 1 ECTS)		
Theoretical classes: ▪ Geophysical Techniques: ground penetrating radar (GPR), electromagnetic induction (EMI), radiometry, electrical tomography (ERT), seismic methods, reflectometry (TDR). ▪ Drone Remote Sensing Techniques: drones, thermal infrared sensors, multispectral sensors, LiDAR. ▪ Topography and Sensors Practical works: The key concepts presented during the classes will be applied during practical sessions (acquisition of operational skills) and as part of a group integrated project.		
Entry requirements		
Applied Geomatics; Soil Physics		
Teaching and learning approach		
▪ Lectures. ▪ Team-based practical work with an integrated project involving the creation of a collective report. ▪ Seminars aimed at delving into a scientific question related to the course and developing professional communication skills.		
Time allocation in hours per activity		
Lecture [contact]	22.5 (+ 10)	
Supervised practical [contact]	15 (+ 5)	
Sum	**37.5 (+ 15)**	
Assessment		
Examiners	Sébastien Lambot	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written Exam	60 (if written exam passed (>10/20), otherwise 100)	Individual
Project Report	20 (if written exam passed (>10/20), otherwise 0)	Group
Seminar	20 (if written exam passed (>10/20), otherwise 0)	Group

Land monitoring by advanced Earth Observation	
Course code	LBRAT2104 | LBRAT2104A
Course type	Compulsory (Track 2 & Track 4)
Period	February 2028 – May 2028
Credits	3 + 1 (Track 2) | 3 (Track 4)
Coordinator	Pierre Defourny, Sophie Bontemps
Keywords	Earth observation | detection | monitoring
Hyperlink	https://uclouvain.be/en-cours-2025-lbrat2104 https://uclouvain.be/en-cours-2025-lbrat2104A

Description

This course aims to develop in-depth understanding and professional skills to process and interpret very high-resolution UAV (drone) imagery and Earth Observation satellite time series. Advanced concepts related to signal acquisition, time series quality control and uncertainty characterization are introduced. Radiative transfer modelling and methods for biophysical variables estimation (Leaf Area Index, biomass, nitrogen status, surface temperature, evapotranspiration, soil moisture, height, etc.) and change detection methods are explained and illustrated through practical applications and the European Copernicus Services. Finally, open source tools and systems supporting already operational and forthcoming monitoring systems, including flood monitoring, fire monitoring, forest monitoring and crop monitoring, are discussed in details. The objective of this course is to develop the necessary knowledge and technical skills to use advanced image processing methods (including machine learning and artificial intelligence) and to implement workflow for UAV or satellite monitoring applications in the field of agriculture, forestry, land use land cover change, and water resources management.

The additional module (1 ECTS) also aims to develop in-depth understanding of the challenges and potential of Earth Observation to support operational agriculture monitoring systems. The strengths, assumptions, and shortcomings of current operational early warning systems and crop monitoring systems are discussed based on a technical analysis of workflows and a quality assessment of input data sources. The European Copernicus Services and the monitoring systems of the European Common Agriculture Policy are analysed. Further developments are designed to better support the agricultural transformation towards sustainable practices. In the context of the big data era designing end-to-end solutions that are fit for purpose is discussed in order to tackle the challenges of sustainable food production.

Learning outcomes

- Build an integrated body of scientific knowledge (knowledge, methods and techniques, models and processes) in environmental and human sciences which serves as the foundation from which to operate with expertise in the field of geoinformation and Earth Observation
- Master highly specialised skills in geoinformation science and Earth Observation which serves as the foundation from which to operate with expertise in the field of environmental, agricultural and land use management
- Formulate and resolve a complex environmental problem with appropriate, sustainable and innovative solutions, the problem being related to the impact of human activities or natural processes on the capacity of the environment to provide goods and services to the population
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors

At the end of this activity, the student is able to:

Land monitoring by advanced Earth Observation
▪ practically mobilize the advanced concepts and methods of airborne and satellite remote sensing applied to the monitoring and the management of natural resources, to regional planning and to the environment in general; ▪ understand and critise in depth the operational services, the available products and the existing tools to get the best out of each; ▪ mastering specialized open-source remote sensing softwares and developing processing chains including several tools; ▪ design and conduct rigorous digital analyses of optical and radar time series to respond to specific issues belonging to the bioengineer fields and to formulate the related hypotheses and limits; ▪ be able to grasp technological developments in the field of remote sensing applied to the fields of the bioengineers.
Content
The course combines lessons and practicals in computing lab mainly based on open source softwares used in the professional sector. The lessons address the following topics: ▪ signal acquisition and pre-processing steps, including quality flags and uncertainty management; ▪ radiative transfer modelling and retrieval of various biophysical variables; ▪ optical and SAR time series analysis, features extraction and pixel-based / object-based metrics; ▪ advanced radar processing including polarimetric and interferometric variables; ▪ introduction to machine learning and artificial intelligence algorithms for Earth observation mapping, monitoring and change detection; ▪ critical review of operational monitoring systems (drought, flooding, fire, forest, crop, locust) and of Copernicus Services freely available. ▪ EO applications related to the environment, agriculture, forestry, water resources and land use planning. The additional module also combines lessons and use case study mainly based on open source software and systems description analysis. The lessons address the following topics among others: ▪ global early warning systems for food security, ▪ rangelands monitoring systems, ▪ national, continental and global crop monitoring systems, ▪ certification support system for regenerative or sustainable agriculture.
Entry requirements
Introductory class in remote sensing; Programming skills (R, python)
Teaching and learning approach
The teaching introduces the concepts and advanced methods while the practicals in computer lab mobilise them in the context of specific applications. The lessons are quite interactive and the practicals rely on an inductive approach based on a case study. The course and the practicals aim to develop on one hand advanced technical skills in Earth observation data processing and on the other hand, the ability of critical analysis with regards existing solutions, services and products. The student learns not only to use open source packages and Google Earth Engine environment but also to assess the quality and to review the validity of the proposed algorithms and datasets for a given application. The practical training is closely linked to the course and includes the use of several open source libraries (including QGIS, SNAP, GDAL, ORFEO, Sen4CAP), the exploitation of the Jupyter notebook environment for quality control and time series analysis, and the workflow coding in Python or R.
Time allocation in hours per activity

Land monitoring by advanced Earth Observation		
Lecture [contact]	22.5 (+ 7.5)	
Supervised practical [contact]	15 (+ 7.5)	
Sum	**37.5 (+ 15)**	
Assessment		
Examiners	**Pierre Defourny, Sophie Bontemps**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Scientific poster based on a case study	100	Individual

Spatial Modelling of land dynamics	
Course code	LBRAT2102
Course type	Compulsory (Track 2 & Track 4)
Period	February 2028 – May 2028
Credits	3
Coordinator	Pierre Defourny
Keywords	Land use | model
Hyperlink	https://uclouvain.be/en-cours-2025-lbrat2102

Description

The course introduces with a critical perspective a representative set of methods of spatial analysis and land use/land cover modelling, addressing both conceptual and numerical aspects. The course primarily aims to train to the conceptualization of a spatial modelling approach on the one hand, and the development of a critical analysis of existing models and simulations on the other hand. Advanced geomatics methods and dynamic modelling tools supporting a multidisciplinary approach to territorial dynamics are privileged, including functional network modelling using geographic information system, dynamic simulation by cellular automata and spatiotemporal modelling using a multi-agent system. Learning at least one macro language opens the student to the development of special tools. Finally, the contribution of simulations and modelling expertise to decision-making process in spatial planning is discussed.

Learning outcomes

- Build an integrated body of scientific knowledge (knowledge, methods and techniques, models and processes) in environmental and human sciences which serves as the foundation from which to operate with expertise in the field of geoinformation and Earth Observation
- Master highly specialised skills in geoinformation science and Earth Observation which serves as the foundation from which to operate with expertise in the field of environmental, agricultural and land use management.
- Formulate and resolve a complex environmental problem with appropriate, sustainable and innovative solutions, the problem being related to the impact of human activities or natural processes on the capacity of the environment to provide goods and services to the population

At the end of the course, students are able to:

- mobilize the concepts and methods of spatial modelling and simulation of land dynamics;
- thoroughly analyse a complex territorial dynamic, to conceptualize a modelling approach and justify the proposed methodological choices;
- develop a critical analysis of operational models and spatial simulation methods in order to clearly determine their relevance and limitations.

Content

The different modelling and numerical simulation approaches for land use/land cover change and other territorial dynamics are presented according to an increasing level of complexity through concrete examples. The concepts and underlying assumptions are presented and put into perspective in relation to potential applications. During the lectures as well as in the computer lab, the student is invited to conceptualize rigorously his modelling approach and to discuss its implementation.

Entry requirements

Applied Geomatics; Basics in statistics

Teaching and learning approach

The course alternates theoretical module in the form of an interactive lecture and practical work module in the computer room (GIS software and modelling tools).

Time allocation in hours per activity

Spatial Modelling of land dynamics		
Lecture [contact]	15	
Supervised practical [contact]	15	
Sum	**30**	
Assessment		
Examiners	Pierre Defourny	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	100	Individual

Landscape ecology	
Course code	LBOE2140
Course type	Compulsory (Track 2)
Period	September 2027 – December 2027
Credits	4
Coordinator	Hans Van Dyck
Keywords	Landscape | Ecology | Habitat
Hyperlink	https://uclouvain.be/en-cours-2025-LBOE2140

Description

The main themes of the course are:
1. Definition and history of landscape ecology
2. Structural components of landscapes: spatial analysis
3. Habitat fragmentation: patterns and consequences
4. Movements by organisms: Structural versus functional connectivity of landscapes
5. Landscape ecology and conservation: ecological networks, corridors and de-fragmentation measures
6. Use of spatial software tools (GIS-applications)
7. Practical applications: bridging the gap between ecological science and policy making/landscape management

Learning outcomes

Landscape ecology addresses how to describe and quantify - and in particular how to understand - ecosystems at the landscape level by analysing biotic, abiotic and human factors.
In this course we particularly focus on the ecological functioning of landscapes within the frame of habitat fragmentation and the mobility of organisms.
Students need to know the key concepts of landscape ecology and need to understand in particular the difference between structural and functional landscape connectivity (in whatever application).
Students should be familiar with the research methods used (empirical and modelling work).
They should also be aware of the potential communication problems between ecologists and non-ecologists in practical multi-disciplinary projects.

Content

This teaching unit focuses on the analysis and understanding of structural variation in landscapes in order to better grasp its functioning for biodiversity components.
The topics covered in these lectures include:
1. Definition and history of landscape ecology;
2. Structural components of landscapes: spatial analysis;
3. Habitat fragmentation;
4. Urbanization;
5. Landscape ecology and conservation: ecological networks, corridors and de-fragmentation measures, structural vs functional connectivity of landscapes;
The pratical part of the course includes:
1. Use of spatial software tools (GIS-applications); and
2. Practical applications in landscape ecology/spatial conservation planning.

Entry requirements

Prior basic knowledge of a Geographic Information System (GIS/SIG, e.g. ArcGIS), or basic skills of using such a computer program.

Teaching and learning approach

This teaching unit consists of two parts that require the presence of the students.

Landscape ecology		
There is a series of theoretical lectures, which make use of a number of PowerPoint presentations. These lectures are given in an interactive way (frequent discussions with students). The other part is a practical course in a computer room supervised by a teaching assistant (exercises in landscape ecology with a GIS-computer system). The presentations and all other relevant information (e.g. manual about the practical course) are available on the Moodle website of this course, as well as a number of scientific papers that are used.		
Time allocation in hours per activity		
Lecture [contact]	30	
Supervised practical [contact]	30	
Sum	**60**	
Assessment		
Examiners	**Hans Van Dyck**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	60	Individual
Report on practical course	40	Individual

Applied Geomatics	
Course code	LBIRE2102
Course type	Compulsory (Track 2 & Track 4)
Period	September 2027 – December 2027
Credits	4
Coordinator	Pierre Defourny
Keywords	Satellite | Cartography | GIS
Hyperlink	https://uclouvain.be/en-cours-2025-LBIRE2102

Description

The Applied Geomatics course includes a professional training from an engineering perspective to geographical information systems (GIS), cartography and satellite remote sensing both in terms of concepts and methods as well as practical use for operational applications in the field of bio-engineering specializations, urban planning and environmental specialists.

The concepts, methods and tools are explained by ex-cathedra teaching and applied in the lab activities. They cover:

- advanced use of GIS and global positioning systems,
- remote sensing of terrestrial surfaces based on their electromagnetic properties and the radiative transfer, with a particular focus on discrimination and the monitoring of vegetation,
- Earth observation by airborne systems and different types of satellites, including radar.
- advanced principles and methods in digital image processing of images and time series analysis

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of environmental management and land use planning.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of environmental management and land use planning.
- Formulate and resolve a complex environmental engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects.

At the end of the course, students are able to:

- thoroughly understand concepts and methods in geomatics applied to environmental systems, study and management of natural resources, land use planning and the environment in general;
- mobilize methods of collection, analysis and representation of spatial data and satellite remote sensing images;
- master professional software for image processing in satellite remote sensing;
- carry out the conceptual analysis of a problem, design and implement a solution including the collection, organization and processing of georeferenced data;
- understand the technological developments in the field of geomatics applied to the fields of bioengineers.

Content

The course consists of four complementary modules:

- Advanced concepts and methods in geographical information systems (GIS)
- Foundation and advanced use of global positioning systems
- Concepts and methods of airborne and satellite remote sensing

Applied Geomatics		
- Practical work mobilizing professional software for both GIS and image processing in remote sensing. **Additional explanation** The English version of the class also includes specific module on advanced topics in the fields of satellite remote sensing.		
Entry requirements		
Basics in statistics. Introduction to geographical information systems (GIS) and digital mapping.		
Teaching and learning approach		
The teaching is based on an inductive approach which starts from the geomatics services which have invaded our daily life (geolocation, web services, online mapping, etc.) in different sectors of activity (monitoring system, forecasting system, reporting, etc.) to then deepen the basic concepts, assumptions and methods of analysis. The objective is to make the learner autonomous and critical in the use of geomatics data and tools as well as in the design and implementation of operational applications. Through the learning of professional software in satellite image processing and geographic information system, the student mobilizes concrete concepts and methods covered in class to exploit geographical databases (GIS), conduct all steps of satellite images interpretation and produce a cartographic output.		
Time allocation in hours per activity		
Lecture [contact]	30	
Supervised practical [contact]	22.5	
Sum	**52.5**	
Assessment		
Examiners	Pierre Defourny	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Oral exam	50	Individual
Practical exam	50	Individual

Advanced geo-processing	
Course code	LGEO2185
Course type	Compulsory (Track 2)
Period	February 2028 – May 2028
Credits	5
Coordinator	Kristof Van Oost
Keywords	GIS | mapping
Hyperlink	https://uclouvain.be/en-cours-2025-LGEO2185

Description

The main objectives of this course are:

- To develop a coherent strategy to asses and solve spatial problems
- To provide a solid foundation for programmatically interacting with GIS platforms
- To provide the most up-to-date tools and information necessary for building and implementing customized geo-processing tools
- To introduce and apply the basic concepts of web mapping services.

Practical/Knowledge skills:

- An ability to perform object-oriented programming tasks
- An ability to program GIS-based models in Python
- An understanding of software engineering concepts and good programming methods
- An awareness of the diversity of approaches in the field of web-based mapping.

Personal skills:

- An aptitude for analytical assessment of spatial problems
- An ability to conceptualize, plan, implement and communicate the results of a GIS-based model.

Learning outcomes

At the end of this learning unit, the student should be able to:

- perform object-oriented programming tasks
- program GIS-based models
- develop and implement a web-based map service

Content

1. Introduction to GIS modelling and Python language.
   a. The need for GIS automation
   b. Python introduction
   c. Objects and object-oriented programming
   d. Examples & Exercise
2. Python and programming basics
   a. Program structures
   b. Troubleshooting
   c. Examples & Exercise
3. Spatial data access and manipulation
4. Programming languages for GIS development
5. Customized GIS application development
6. Web map Services

Entry requirements

Knowledge of GIS

Teaching and learning approach

The course is organized around three modules:

Advanced geo-processing		
5) Lectures: During the lectures, the basic and theoretical concepts and background of GIS programming will be introduced. ii) Hands-on practical exercises: Assignments will give students an opportunity to internalize and apply the concepts and theory learned. iii) Final project. This project presents an opportunity to integrate the course content and consists of a proposal, a final report and presentation.		
Time allocation in hours per activity		
Lecture [contact]	30	
Supervised practical [contact]	30	
Sum	**60**	
Assessment		
The student should expect this class to be both academically robust and intellectually challenging. The main theoretical concepts will be provided through course notes and presentations. Learning will arise from active engagement with this knowledge during the hands-on practical exercises. A final project aims at integrating the course material in a personalized way. In the Final Projects the student will: 1. Frame a spatial question or application scenario that can be solved using a customized GIS application or geo-processing function. 2. Collect appropriate spatial and non-spatial data to be used as input. 3. Determine the technologies/tools to be used. 4. Establish the important intermediate steps in programming and implementation, including testing/debugging. 5. Produce a working application that implements your approach		
Examiners	Kristof Van Oost	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Project	100	Individual

Project management	
Course code	LBIRE2205B
Course type	Compulsory (Track 2)
Period	September 2027 – December 2027
Credits	1
Coordinator	Raphaël Amory
Keywords	Project | management
Hyperlink	https://uclouvain.be/en-cours-2025-lbire2205B

Description

- Mastering the project approach as an intervention mean in industrialized and developing countries, linked to their specific social, political and environmental context
- Mastering the successive steps of the life cycle of the project, integrating all these elements in a systematic pattern with a view to a feasibility analysis.
- Mastering the methods of project follow-up and assessment, including financial and economic assessment.
- Knowing the basics of planning methods and human resource management.

Learning outcomes

- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.

Content

Stemming from the professional activity of the bio-engineer, the course outlines the project-based approach in a context of rural development or environmental management by public or private actors. The project-based approach is defined in contrast with other modes of intervention and outlined through the project life-cycle (identification, design, feasibility, programming, funding, implementation, follow-up, assessment). The incentives of various actors (fund raisers, field workers, target groups, etc.) and institutional partnerships are analysed.
Lectures emphasize the criteria and the methods for an impact assessment, and the practical implementation thereof. Critical analyses are performed by the students on case studies in the realms of rural development and the environment, so that they develop a professional attitude towards these problems. Finally, drawing from practical examples, lectures describe the methods for the identification, the design and the study of feasibility at the technical, environmental, organisational, social, financial and economic levels. Some legal and normative aspects are discussed.

Methods and tools are presented on the basis of the following schedule:

- basic definitions and concepts: project, program, project management, project life-cycle, strategies, stakeholders, resources, etc.

Project management		
▪ Strategic planning and programming ▪ Identification of projects, the idea of a project, the problem tree, the target tree ▪ Planning: strategies, indices, WBS organigram, GANTT diagram, risk analysis, budget, quality planning, organisational and managerial aspects, monitoring ▪ Implementation: launch, actor roles, organisational modes, risk/conflict/change management, communication ▪ Follow-up, monitoring, reporting ▪ Ex-post assessment		
Entry requirements		
Knowledge and know-how in basic courses of the bio-engineering programme		
Teaching and learning approach		
Explanation of theoretical concepts and application to real-life examples.		
Time allocation in hours per activity		
Lecture [contact]	15	
Sum	**15**	
Assessment		
Examiners	Raphaël Amory	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Take-home exam	100	Individual

Soil erosion and conservation	
Course code	LBRES2105
Course type	Elective (Track 2)
Period	February 2028 – May 2028
Credits	4
Coordinator	Charles Bielders
Keywords	Soil | erosion | conservation
Hyperlink	https://uclouvain.be/en-cours-2025-LBRES2105

Description

Main themes of the course:
- Water, wind and tillage erosion : physical processes and quantification
- Modelling of water erosion at plot and watershed scale
- Principles of soil conservation in temperate and tropical environments
- Soil conservation techniques and practices : physical, agronomical, vegetative, and management practices

Learning outcomes

- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of the course and practicals, the students:

- Will master the main mechanisms involved in the degradation of soil by water, wind and tillage erosion;
- Will be able to propose a methodology on an experimental basis to quantify land degradation by water erosion at the plot scale or watershed;
- Will be able to implement a simple model of water erosion in a GIS to assess the risk of erosion at the scale of the plot or watershed;
- Will master the principles of soil conservation and will be able to propose practices, technologies or devices adapted to the socio-economic and technical context of operators and aiming at reducing erosion at the plot and watershed scale;
- Be able to communicate the results and conclusions of the simulations and experiments in the form of tables, graphs and scientific diagrams in a written report reflecting mastery of software tools essential for effective professional communication.
- be able to position himself with respect to the management of soil erosion and muddy floods

Content

Lectures

- Definitions, on- and off-site consequences of water erosion
- Forms of water erosion: interrill, rill, gully
- Factors of water erosion: rain, soil, terrain, cultural practices, crop

Soil erosion and conservation		
▪ Processes: detachment, transportation, storage ▪ Measurement of erosion ▪ Empirical (RUSLE) and deterministic modelling ▪ Principles and methods of soil conservation - Wind erosion (2h) - Tillage erosion (2h) As part of the section on water erosion, a collective brainstorming will be conducted around the fictional development of a site subject to muddy floods. The discussion will focus on the challenges of mastering soil erosion, actors and levers. Through role play, students will be encouraged to think about the complexity of managing an environmental issue. **Practicals** Soil Conservation ▪ Use of the RUSLE model on simple and complex slopes, and management of a small virtual watershed ▪ Evaluation of a grass strip ▪ Measurement of saltation (wind erosion) ▪ Estimation of tillage erosion on complex slope (spreadsheet)		
Entry requirements		
Spreadsheet management (ExcelTM) Basic use of Geographical information system Basic knowledge in soil science		
Teaching and learning approach		
▪ Practical work in the computer room lead the student to operational use of the RUSLE model. ▪ Practical work in the laboratory (grass strip, wind erosion) ▪ Exercise sessions (tillage erosion) ▪ The practicals, to be carried out in a team, and report writing stimulate collective work and the development of skills related to professional communication; ▪ Role play regarding the management of soil erosion for a fictitious site		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	22.5	
Sum	**45**	
Assessment		
Examiners	**Charles Bielders**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Oral exam	40	Individual
Evaluation of practicals based on written report	40	Individual
Participation in role play	20	Group

Impact evaluation in agriculture	
Course code	LBRAI2213
Course type	Elective (Track 2)
Period	February 2028 – May 2028
Credits	4
Coordinator	Goedele Van den Broeck
Keywords	Impact | agriculture | policies
Hyperlink	https://uclouvain.be/en-cours-2025-LBRAI2213

Description

Importance of impact evaluation, different evaluation methods (randomized assignment of treatment, instrumental variable estimation, difference-in-difference estimation, propensity score matching, regression discontinuity design), implementation of impact evaluation. All illustrations and applications are drawn from agricultural policies, programs and projects.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach

At the end of the course, students will be able :

- to understand the importance of impact evaluation for developing sound agricultural and food policy
- to know, understand and explain the different evaluation methods and how to construct a convincing counterfactual
- to critically compare the advantages and disadvantages associated with the different evaluation methods
- to know, understand and explain how to implement an impact evaluation in agriculture, specifically how to collect data, design a farm survey and develop a sampling strategy

Content

Impact evaluation in agriculture		
▪ Students are exposed to the theory behind impact evaluation, illustrated by many real-life applications of agricultural policies, programs and projects. ▪ Students read and discuss selected scientific publications that use different evaluation methods to critically reflect about the implementation of impact evaluations in various contexts. ▪ External guest speakers from various NGOs, development agencies and research institutes will share their professional expertise with impact evaluation to familiarize students with a non-academic perspective on impact evaluation.		
Entry requirements		
Micro-economics and Introduction to econometrics		
Teaching and learning approach		
Teaching in class room, directed reading, group discussions, presentations		
Time allocation in hours per activity		
Lecture [contact]	30	
Supervised practical [contact]	8	
Sum	**38**	
Assessment		
Examiners	**Goedele Van den Broeck**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Discussion about evaluation plan submitted in advance by the student	100	Individual

Process-based modelling in bioscience engineering	
Course code	LBRTI2102
Course type	Compulsory (Track 4)
Period	September 2027 – December 2027
Credits	5
Coordinator	Emmanuel Hanert
Keywords	Model
Hyperlink	https://uclouvain.be/en-cours-2025-LBRTI2102

Description

This module will help students to develop a thorough knowledge of the different steps required to setup a model and learn how to use simulation tools. The students will be able to setup a complete modelling approach in order to forecast and anticipate the behaviour of complex systems. This module considers the propagation of errors and uncertainties in models and hence allows estimating the risk associated to a particular decision.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

By the end of the course, students will be able to:

- Name, describe, explain the theoretical concepts related to the mechanistic approach to analyse and model environmental processes;
- Explain mathematical concepts and use computational tools to model the space-time dynamics of these processes;
- Use these concepts and tools in an operational fashion in order to model the processes that drive realistic environmental systems in the context of an individual project;
- Present a detailed justification of the methodological choices that have been made to analyse the system under study;
- Write a brief report, with a solid discussion based on the modelling results and appropriately illustrated with graphs and charts, using accurate and appropriate scientific vocabulary.

Content

The course covers the following elements and illustrates them with examples modelled with Python:

- Application of mathematical models in ecology: logistic growth - predator-prey models and general Lotka-Volterra models applied to multi-populations systems.
- Application of mathematical models in epidemiology: compartments models - population dynamics (epidemics vs endemic states) - reproduction number (R_0).
- Transport models in 1D and 2D, and numerical discretization of the advection, diffusion and reaction terms.
- Application of transport models in ecology, epidemiology and hydrodynamics.
- Cellular automata models and their application to simulate outbreaks and invasive species.

Entry requirements

Process-based modelling in bioscience engineering		
Basic courses in mathematics and some knowledge of the Python programming language		
Teaching and learning approach		
Teaching is based on a two-hour lecture each week. The lecture format is very "hands-on" with many practical examples and illustrations. Students are encouraged to take their laptop in the classroom. Practical sessions with a research assistant are also scheduled to help the students apply the concepts presented during the lectures.		
Time allocation in hours per activity		
Lecture [contact]	30	
Supervised practical [contact]	15	
Sum	**45**	
Assessment		
Examiners	Emmanuel Hanert	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Individual report on a personal project	70	Group of 2
Oral exam	30	Individual

Fundamentals of geographic and environmental modelling	
Course code	LGEO2130
Course type	Compulsory (Track 4)
Period	February 2028 - May 2028
Credits	5
Coordinator	Deleersnijder Eric, Vanwambeke Sophie
Keywords	Math | Model
Hyperlink	https://uclouvain.be/en-cours-2025-LGEO2130

Description

The course focuses on differential models, spatial modelling and modelling practice. The course starts by a general introduction on modelling.

Learning outcomes

At the end of this course, the student will be able to:

- Identify and characterize a model and understand the mathematics of a process-based model;
- Translate a physical, environmental and/or spatial process into mathematical language;
- Grasp all steps of a modelling process, from the statement of a question to the validation of results;
- Start engaging with professionals of environmental modelling and management in various settings.

Content

The course includes two parts. The first half focuses on differential models. The second half looks into spatial modelling and modelling practice. The course starts by a general introduction on modelling.
The following topics are dealt with:

- How to model? The various steps of modelling;
- Typology of models;
- Differential models: linear ordinary differential problems (e.g. first order decay);
- Differential models: non-linear ordinary differential problems (e.g. population modelling, prey-predator populations, epidemiological model);
- Differential models: space-time dependency;
- Spatial models: making space explicit, self-organising systems (e.g. epidemic diffusion, erosion processes);
- Spatial models: interacting, spatially-explicit objects: agent-based models (e.g. land use change)
- How to model? Model validation.

Entry requirements

Elementary calculus and statistics. Geographical Information Systems

Teaching and learning approach

Classroom lectures and practical sessions, involving active learning methods.

Time allocation in hours per activity

Lecture [contact]	30
Supervised practical [contact]	30
Sum	**60**

Assessment

Examiners	Deleersnijder Eric; Vanwambeke Sophie

Fundamentals of geographic and environmental modelling		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Math homework	5	individual
Homeworks on part 1	35	individual
Reports on part 2	40	individual
Joint oral exam on both parts	20	individual

Algorithms in data science	
Course code	LINMA2472
Course type	Elective (Track 4)
Period	September 2027 – December 2027
Credits	5
Coordinator	Benoît Legat
Keywords	Data | algorithm
Hyperlink	https://uclouvain.be/en-cours-2025-LINMA2472

Description

The course explores questions, mainly of an algorithmic nature, regarding the challenges offered by the emergence of Big Data.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.

More specifically, at the end of the course the student will be able to:

- read a general or specialized literature on a specific cutting-edge theme of discrete mathematics, and summarize the key messages and results
- explain those messages to their peers in a clear and precise way
- solve mathematical problems in application to those results
- identify the possible caveats of those results and criticize the exposition chosen by the references
- relate the concepts encountered in the literature to concepts covered in other course, despite different notations or viewpoints
- implement algorithms on real data and take a critical look at the results;
- demonstrate critical thinking with regard to a technology and the environmental and societal impacts it represents.

The mathematical objectives can change from year to year.

Content

This course explores automatic differentiation (AD), the core technology powering modern machine learning. Students will learn how AD works from the ground up, starting with scalar and tensor-based approaches, and progressing to second-order and sparse techniques. The course also covers differentiating optimization programs. Through hands-on projects, students will implement their own AD system from scratch and use it to train neural networks and transformers.

Algorithms in data science		
The course also introduces kernel methods as a classical approach to learning in high-dimensional spaces. It concludes with an exploration of generative models for unsupervised learning tasks such as image generation, including generative adversarial networks (GANs), variational autoencoders (VAEs), and diffusion models.		
Entry requirements		
Familiarity with mathematics and algorithmics of the common core of the Bachelor of Engineering or Computer Science is required. More particularly in linear algebra and analysis, probability, discrete mathematics, algorithmics and basic programming		
Teaching and learning approach		
Ex cathedra lectures that introduce the concepts and algorithms along with their theoretical foundations, and projects with written and/or oral reports. These projects involve a significant amount of implementation (in Python and Julia). Prior knowledge of either language is not required, but a solid background in programming is essential. Tutorials are provided to help students get started with the necessary tools.		
Time allocation in hours per activity		
Lecture [contact]	30	
Group assignment	22.5	
Sum	**52.5**	
Assessment		
Examiners	Jean-Charles Delvenne, Vincent Blondel	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Work carried out during the term	50	Individual
Written or oral exam	50	Individual

Introduction to the physics of the climate system and its modelling		
Course code	LPHYS2162	
Course type	Elective (Track 4)	
Period	September 2027 – December 2027	
Credits	5	
Coordinator	Hugues Goosse	
Keywords	Physics | Climate | Model	
Hyperlink	https://uclouvain.be/en-cours-2025-LPHYS2162	
Description		
The main themes of this course are: ▪ Description of the climate system and its components ▪ Energy balance ▪ Hydrological cycle and carbon cycle ▪ Key feedback mechanisms and climate sensitivity to external perturbation ▪ Natural variability of climate at all time scales ▪ Hierarchy of models of the climate system ▪ Greenhouse effect and climate change induced by human activities.		
Learning outcomes		
At the end of this teaching unit, the student will be able to: 1. describe the main interactions between the components of the climate system; 2. develop a simple model of the climate system; 3. simulate the behaviour of the climate system at various time scales; 4. choose the appropriate model according to the climatic problem; 5. estimate the uncertainties of observations and climate models; 6. assess the relevance of a climate theory based on available information; 7. structure the results of a model of a complex system.		
Content		
1. Description of the climate system and its components 2. Energy balance, water cycle and carbon cycle 3. Modelling of the climate system 4. Response of the climate system to a perturbation 5. Brief history of climate: causes and mechanisms 6. Future climate change		
Entry requirements		
Strong foundation in physics		
Teaching and learning approach		
Lectures, integrative project, computer simulation sessions, online exercises, articles to read.		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	22.5	
Sum	**45**	
Assessment		
Examiners	Goosse Hugues; Massonnet François	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**

Introduction to the physics of the climate system and its modelling		
Different types of evaluations can be proposed by the teaching team:		
Written exam	variable from year to year	individual
Oral exam	variable from year to year	individual
Project report	variable from year to year	individual

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