Complex Systems Profile

Description and aims

The Master's profile Complex Systems is an interdisciplinary profile for students who are interested to broaden their knowledge and expertise within the field of Complex Systems. In this research field societal issues, such as a financial crisis, a sudden epidemic or climate change are studied from a quantitative modelling perspective. Students will get an understanding of the various models used in the complexity field and the behaviour (i.e. transitions, predictability) of these models.

The aim of the Complex Systems Profile is for students to develop or improve their

- affinity for quantitative approaches in order to address societal issues,
- ability to build models that are amenable to quantitative approaches,
- familiarity with standard (quantitative) methods in the toolbox for analysing complex systems, and
- ability to work in interdisciplinary teams.

Learning outcomes

Upon completion of the Master's profile the student

- is able to recognise the complex systems aspects when confronted with a societal problem,
- is able to develop models of complex systems and/o has a good overview of model-building for complex systems,
- has a good overview of the methods in the complex systems toolbox, can apply them to models and extract quantitative results, and
- communicate/explain complex-systems models and methods to (interdisciplinary) teammates.

Programme

The Master's profile comprises 30 EC and consists of the following parts:

- Two electives (7.5 EC each) from the following courses (**one of these electives need to be from 1-3 below**, which are termed as **core courses** for Complex Systems):
  1. Introduction to Complex Systems (WISM484)
  2. Advanced Topics in Climate Physics[1] (NS-MO411)
  3. Computational Aspects of Machine Learning[2] (NS-EX426M)
  4. A Complex Systems labelled course listed under a master programme that is **different** from the one to which the student is admitted (see list below). **Note on this list:** some programmes may require one of their own primary elective courses, labelled as Complex Systems course to be taken; the student **cannot** count them as primary electives **as well as** Complex Systems master profile courses. More information can be found in the specific programme description section of the Education and Examination Regulations.
- A Research Project on a Complex Systems topic (15 EC, Osiris code GSNS-CSRP), for which focus should be on interdisciplinary aspects and at least two supervisors from two different departments/faculties must be involved.

  The topic should not correspond to the topic of the master thesis, however if the master research project deals with a complex system subject – currently available only for Theoretical Physics, Experimental Physics and Climate Physics Master programmes at Utrecht University – it is permitted to combine the research project of the master's profile Complex Systems (15 EC) with the master thesis project. In case the master research

[1] In the academic year 2021-22, the course topic is socio-economical modelling of climate change impacts. CLPH students cannot claim it as their primary elective *as well as* a Complex Systems master profile course.

[2] EXPH and THPH students cannot claim it as their primary elective *as well as* a Complex Systems master profile course.

project deals with a complex system subject, the complex systems aspects must be separately assessed and a supervisor from a different department or faculty other than the department related to the student's master programme needs to be involved in assessing the complex system aspects of the research project.

The topic must be approved by the coordinator of the profile as well as by the coordinator of the master programme to which the student is admitted.

The total number of EC of each master's programme will NOT be increased by completing the master profile Complex Systems. Students receive a certificate by completing the Master's profile Complex Systems.

List of courses labelled as a complex systems course

Master's programme	Course	Osiris code
Artificial Intelligence	Evolutionary Computing	INFOEA
Climate Physics	Wave Attractors	NS-MO447M
Computing Science	Data Mining Pattern Recognition Network Science	INFOMDM INFOMPR INFOMNWSC
Energy Science	Energy Systems Modelling	GEO4-2515
Experimental Physics	Modelling and Simulation	NS-TP432M
Game and Media Technology	Pattern Recognition Crowd Simulation	INFOMPR INFOMCRWS
Mathematical Sciences	Inverse Problems in Imaging* Mathematical Biology* Introduction to Numerical Bifurcation Analysis of ODEs and Maps*	WISL435 WISL411 WISL606
Nanomaterials Science	Toy Models Modelling and Simulation	SK-MTOYM NS-TP432M
Sustainable Development	Systems Thinking, Scenarios and Indicators Environmental Systems Analysis	GEO4-2331 GEO4-2303
Theoretical Physics	Modelling and Simulation	NS-TP432M
Multidisciplinary Economics	Algorithms in Finance The Triumph of the City	ECMAF ECRMTCE

* Registration via elo.mastermath.nl

Entry requirements

- The student belongs to one of the participating master programmes
- Upon consultation with the coordinator for the profile, it is also possible for students from outside Utrecht University to participate in the profile, when their master programme has an affinity to complex systems

Participating Master's programmes

- Climate Physics
- Computing Science
- Energy Science
- Artificial Intelligence
- Experimental Physics
- Game and Media Technology
- Mathematical Sciences
- Nanomaterials Science
- Sociology and Social Research
- Sustainable Development
- Theoretical Physics
- Multidisciplinary Economics

Legacy issues

The following courses were labelled as Complex Systems courses in the past academic years (noted in parenthesis).

Master's programme	Course	Osiris code
Artificial Intelligence	Seminar Social Simulation (2018-19)	INFOMSOCS
Core courses	Applying Mathematics in Finance (2017-18), Algorithms in Finance (2018-19, 2019-20)	WISM410
	Complex Networks (2020-21)	WISL115
	Seminar Applications of Mathematics in Radiation Research (2017-18, 2018-19, 2019-20)	WISM409
	Understanding Complexity: Economy and the Planet (2016-17, 2017-18, 2018-19, 2019-20)	NS-MO450M
Computing Science	Evolutionary Algorithms (2018-19, 2019-20), Evolutionary Computing	INFOEA
Game and Media Technology	Games and Agents (2017-18)	INFOMGMAG
Mathematical Sciences	Interacting particle systems: Theory and applications (2018-19)	WISL431
	Introduction to Numerical Bifurcation Analysis of ODEs and Maps (2017-18, 2019-20)	WISL606
	Inverse Problems in Imaging (2020-21)	WISL430
	Laboratory class for scientific computing (2018-19)	WISM454
	Mathematical Biology (2017-18, 2019-20)	WISL411
	Mathematical Neuroscience	WISL413
	Nonlinear Waves (2017-18)	WISL409
	Numerical bifurcation analysis of large-scale systems (2018-19, 2020-21)	WISL425
	Seminar mathematical epidemiology (2017-18)	WISM436
Multidisciplinary Economics	Advanced behavioural and experimental finance (2017-18, 2018-19)	ECRMABEF
Sustainable Development	Sustainability Modelling and Indicators (2018-19, 2019-20)	GEO4-2331