Course directory 2023.2024

School of Biology (FBM-BIO) Master

> Master of Science (MSc) in Behaviour, Evolution and Conservation, Specialisation Geosciences, Ecology and Environment

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SUMMARY

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NOTICE

This course catalogue was produced using data from the *SylviaAcad* information system of the University of Lausanne. Its database contains all information about courses proposed by the different faculties and their times. This data can also be consulted online at the address :
https://applicationspub.unil.ch/interpub/noauth/php/Ud/index.php.

Web site of the faculty : **http://www.unil.ch/ecoledebiologie/**

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LEGEND

NAME OF THE COURSE

Teacher

Type of course	Status	Hours per week	Teaching language	Hours per year
Semester	Credits			

N: Levels

P: Programme requirements

O: Objective

C: Content

B: Bibliography

I: Additional information

ABBREVIATIONS

TYPE OF COURSE

Attest.	Attestation
C	Course
C/S	Course - seminar
Cp	Camp
E	Exercises
Exc	Excursion
Lg	Guided lecture
S	Seminar
T	Fieldwork
TP	Practical work

STATUS

Fac	Facultative
Obl	Compulsory
Opt	Optional
Fac/Comp/Opt	Facultative, compulsory or optional (according to the study programme)

SEMESTER

Sp	Spring
A	Autumn

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Ecole de biologie

Master of Science in Behaviour, Evolution and Conservation
Specialisation Geosciences, Ecology and Environment
2023-2024

The Master program has a normal duration of 4 semesters and comprises 120 ECTS :

Module 1 : 15 ECTS : Compulsory Courses and one Interdisciplinary Course from the choice list
Module 2 : 15 ECTS : Practical Project
Module 3 : 40 ECTS : Compulsory Courses (7 ECTS) and Optional Courses (33 ECTS)
Module 4 : 50 ECTS : Personal Research Project

For specialisation Geosciences, Ecology and Environment (GEE), the student must :
- Obtain **30 ECTS** in the specialisation :
  - Module 1 : 6 ECTS with Compulsory Courses (marked in pink) and one Interdisciplinary Course of the choice list (marked in green)
  - Module 3 : 7 ECTS with Compulsory Courses (marked in pink) and
    17 ECTS with Optional courses with Disciplinary (marked in pink) and Interdisciplinary (marked in green) Optional Courses
- Carry out the First Step Research Project (Module 2) and the Master Research Project (Module 4) in the field of Geosciences, Ecology and Environment, validated by the head of GEE specialisation

Training objectives are available in its programme regulations.

Specific training objectives: At the end of the course the students will be able to :
- Solve complex ecological problems through quantitative and modelling approaches, using complementary knowledge acquired in geosciences and environmental sciences
- Have an integrated view of natural systems and conduct interdisciplinary research projects in ecology / environment
- Transfer scientific knowledge and skills acquired to applied problems in the field of ecology, environment and conservation

MODULE 1

Compulsory Courses / *Enseignements obligatoires*	Hours per semester C	E	S	PW	Teaching Staff	ECTS	Limited nb of students
Semester 1 (Autumn) / *Semestre 1 (automne)*							
Concepts in Ecology *Concepts en écologie*	6	-	-	-	**Bertelsmeier C.**	2	
Concepts in Evolution *Concepts en évolution*	6	-	-	-	**Schwander T.**	2	
Data Analysis (MSc MLS) *Analyses de données (MSc MLS)*	8	8	-	-	**Bergmann S.**	3	
Introduction to Scientific Writing *Introduction à la rédaction scientifique*	7	9	-	-	**Roulin A.**	2	
Spatial Analysis and GIS in Ecology *Analyses spatiales et SIG en écologie*	7	10	-	-	**Guisan A.**	2	
Master BEC Retreat *Retraite Master BEC*	-	-	-	-	**Kawecki T.**	-	
Animal Experimentation and Wild Animals * *Expérimentation animale et animaux sauvages*	20	-	-	20	**Rubin J.-F.**	-	
Introduction to R (optional support) *Introduction à R (mise à niveau optionnelle)*					**Schütz F.**	-	
Choose one of these courses :							
Soil and Water Chemistry (GSE, MSc in Environm. Sci.) *Chimie du sol et de l'eau*	40 CPW				**Keiluweit M.**, Vittoz P.	4	
Environmental time-series analysis (GSE, MSc in Environm. Sci.) *Traitement du signal et analyse de séries temporelles*	48 CPW				**Irving J.**	5	
Remote sensing of Earth systems (GSE, MSc in Environm. Sci.) *Télédétection des systèmes terrestres*	48 CPW				**Mariethoz G., Antoniazza G., Lane S.**	5	
Total **						**15**	

MODULE 2

Practical Project / *Travail pratique*	C	E	S	PW	Teaching Staff	ECTS	Limited nb of students
Semester 1 (Autumn) / *Semestre 1 (automne)*							
First Step Research Project *Travail d'initiation à la recherche*	-	-	-	224	**Kawecki T.**	15	
Total						**15**	

Disciplinary courses marked in pink
Interdisciplinary courses marked in green

* Only students assigned a master project involving animal experimentation may and must take this course
** Only 15 ECTS will be validated, despite the overrun of one credit. That is independ of the School of Biology

Abbreviations
C = Course
E= Exercise
S = Seminar
PW = Practical Work
CPW or CE or CSE or F = Course/Practical Work or Course/Exercise or Course/Seminar/Exercise or Field

The pandemic has shown us that circumstances beyond our control may require us to make the following adjustments / adaptations to study plans during the semester:

- possibility to switch from one mode of teaching to another (face-to-face <-> distance, synchronous <-> asynchronous, switch to co-modal teaching where it was not initially planned).
- change / modification of evaluation modalities, without inducing derogations from the Study Regulations (oral <-> written, exam <-> validation, individual work <-> group work, practical work <-> theoretical work, face-to-face evaluation <-> online evaluation, etc.)
- alternative or time-shifted modalities for teachings, internships, practical work, fieldworks and camps that could not take place or teachings that could no longer take place in the form initially planned.

Students are invited to consult this document regularly (Study Plan & Evaluation Procedure)

CONCEPTS IN ECOLOGY

Cleo Bertelsmeier

C	Obl	English	6
A	2		

N: Master

CONCEPTS IN EVOLUTION

Tanja Schwander

C	Obl	English	6
A	2		

N: Master

DATA ANALYSIS

Sven Bergmann

C	Obl/Opt		English	8
A	2/3			

E	Obl/Opt		English	8
A				

N: Master

P: We assume nothing more than the mathematics you would have obtained in your studies when you were 18.

O: In this course the goal is to be able to formulate hypotheses properly, design experiments, whether in the laboratory, in a clinic, or in the filed, that have sufficient power to test these hypotheses, conduct appropriate statistical tests of the data generated, generate clear figures, and interpret the results obtained.

C: We will cover:
1. Distributions and random variables
2. Variance, covariance and measures of association
3. Constructing statistical tests using distributions
4. Regression
5. Non-linear regression

INTRODUCTION TO SCIENTIFIC WRITING

Alexandre Roulin

C	Obl	English	7
A	2		

E	Obl	English	9
A			

N: Master

P: Lecturing and paper writing are in English.

O: This short but intensive block course introduces students to the practice of scientific writing (and aspects related to publishing in peer-reviewed scientific journals). We will discuss questions/topics such as: - Why is it important to publish? - What is good/clear versus bad/unclear (scientific) writing? - How to learn how to write well? - How to structure and write a good scientific manuscript? - The submission, editorial and reviewing process. - How to review someone else's paper? - Plagiarism and publication ethics Publishing is of key importance in scientific research: your job as a scientist is not finished until you have published your results - science is to a very large extent about effectively communicating your results and insights, i.e. what you have learned about how nature works. The ultimate aim of this intensive course is thus to equip students with a solid understanding of how to effectively communicate their research in writing.

C: Course Content

The course includes both lectures and practical exercises in class, distributed over four half-days. The lectures will give a broad and brief overview of different aspects of scientific writing and publishing as well as on plagiarism and publication ethics; however, the major emphasis of the course is on practical work on the part of the students. During the practical parts the students will learn, from scratch, the fundamental structure and essential components of scientific writing, how to write effective outlines/drafts and - most importantly - how to write complete, clear, well-structured papers. These practical exercises will thus require students to do reading and writing assignments, often under a bit of time pressure.

At the beginning the exercises will be worked on by teams of 2-4; towards the end, each student will work individually. Finally, to get a grade for this class, students will have to complete a written report (homework assignment). For each exercise as well as for the written report we will give detailed and individualized feedback. Note that all lecturing and assignment writing are in English.

Detailed Programme

Module 1: Lecture 1: Writing papers: overview of why and how.

We will discuss the following: Overview of class and organizational things (incl. homework assignments). Why is it important to publish? What is good/clear versus bad/unclear (scientific) writing? How to learn how to write well? [We will also briefly touch upon issues of good scientific practice and conduct, and various ethical issues connected to publishing.] Approx. 2 hours.

Module 1: Practical 1. Summarise a paper: title, keywords, abstract.

In groups of 2-3. Read the assigned (stripped down and short) manuscript and come up with a title and with keywords. Then write a short abstract (< 200 words). Approx. 1.5 hours. We will then discuss the solutions you have come up with, and their potential pros and cons, together in class. Approx. 30 mins.

Module 2: Lecture 2: Writing papers: details on structure, drafting, revising.

We will discuss the basics and essentials of writing a scientific paper (and also what not to do!). Specifically, I will explain how a paper should be structured and sub-structured, how to draft a paper (i.e., how to get started), how to build and complete a full manuscript, and then how to improve it by continuous and aggressive revising and re-revising. I will also give you hints and tips for effective writing. Approx. 1.5 hours.

Module 2: Practical 2. Write a paper: your own nano-paper from results.

I will give you some data/results (e.g., data figures/tables/legends/statistical outcomes) to choose from. Form teams of 3-4 people. Ask yourself: What do the results/tables/figures/analyses show and mean? Then prepare a very short nano-paper (2 pages max), including: Title, Abstract, Introduction, Materials and Methods, Results, Discussion and Conclusion (there are some other components in a paper that we will skip for the sake of this exercise). Each component should be between 1 and 3-4 sentences maximum. Approx. 2 hours. We will then discuss your solutions and their potential pros and cons together in class; Approx. 30 mins. We will then give you detailed feedback on your papers by e-mail after the course.

Module 3: Lecture 3: Publishing papers: understanding the whole process.

We will briefly recapitulate what we have discussed and learned so far, and then focus on the 'final' stages of writing a paper and submitting it to a journal. Approx. 1 hour

Module 3: Practical 3: Review a paper: critically assess a manuscript.

What distinguishes a good from a bad manuscript? Now you are the reviewer! Being a critical reviewer will help you to learn to distinguish between good and bad writing and thus help you to improve your own scientific writing. You will be given a short, stripped-down manuscript. Team up in groups of 2-3. Read both manuscripts critically, then make pro and contra lists for both manuscripts. Briefly explain why you would accept/reject (or reach some other decision) the manuscript for publication (

SPATIAL ANALYSIS AND GIS IN ECOLOGY

Antoine Guisan

E	Obl/Opt	English	10
A			

C	Obl/Opt	English	7
A	1.5/2		

N: Master

P: Basics in statistics and ecology

O: Teaching students the basics of GIS and remote sensing, as well as the main spatial methods available in spatial ecology.

C: 1. Introduction to GIS
2. Introduction to remote sensing
3. Raster analyses
4. Neighbourhood analyses
5. Spatial interpolation
6. Detection of spatial structures and patterns

B: Wadsworth, R. & Treweek, J. 1999. Geographical Information Systems for Ecology
Caloz, R. & Collet, C. 2002. Précis de télédetection, vol. 3. Presses Univ. du Québec
Turner, Gardner, O'Neill 2001. Landscape Ecology in Theory and Practice: Patterns and Process. Springer
Dale, Birks, Wiens 2000. Spatial Pattern Analysis in Plant Ecology. Cambridge University Press.
Klopatek, J.M. & Gardner, R.H. 1999. Landscape Ecological Analysis: isuues and applications. Springer.
Hunsaker, C.T., Goodchild, M.F., Friedl, M.A. and Case, T.J. (Eds). 2001. Spatial uncertainty in ecology. Springer.
Hansson, L., Fahrig, L. and Merriam, G. 1995. Mosaic Landscapes and Ecological Processes. Chapman & Hall.

I: http://www.unil.ch/ecospat

SOIL AND WATER CHEMISTRY

Marco Keiluweit

C/E	Opt		French	39
A	4			

N: Master

ENVIRONMENTAL TIME-SERIES ANALYSIS

James Irving

C/TP	Opt		4	English	48
A	5				

N: Master

O: Ce cours fournit une introduction à l'analyse des séries temporelles et au traitement du signal pour les sciences de l'environnement. Les sujets à couvrir, dans le contexte des exemples environnementaux pertinents, comprennent l'analyse linéaire des systèmes et des signaux, la convolution, la transformée de Fourier, l'auto-corrélation et la corrélation croisée, le filtrage, la conception des filtres, l'échantillonnage et la reconstruction du signal, l'estimation spectrale, et l'analyse temps-fréquence. Les concepts appris lors des cours seront renforcés par des exercices informatiques.

REMOTE SENSING OF EARTH SYSTEMS

Gilles Antoniazza, Stuart Lane, Grégoire Mariéthoz

C/TP	Opt	4	English	48
A	5			

N: Master

P: Bases in remote sensing, use of Matlab and/or other scripting languages

O: The aim of this course is to provide advanced knowledge of some specific methods used in remote sensing. This will include retrieval and processing of satellite data, data acquisition techniques such as photogrammetry, Structure-From-Motion and methods used as well as computer-aided processing and visualization of remote sensing data.

C: At the end of this course, students will: - Be able to locate and download satellite imagery, and apply treatment to such images in order to extract information; - Be familiar with platforms such as USGS GLOVIS and Google Earth Engine; - Be able to use advanced software tools such as the Matlab Image Processing Toolbox for the processing of remote sensing data; - Be able to apply standard methodologies such as classification, pansharpening, interpolation, edge detection or filters, among others; - Have the ability to apply and understand the principles of photogrammetry.

B: - T. Lillesand, R. Kiefer, J. Chipman, 2015, Remote Sensing and Image Interpretation, Wiley. - J. Campbell & R. Whyne, 2011, Introduction to Remote Sensing, Guilford Press.- M-C Girard et C-M Girard, 2010, Traitement des données de télédétection, Dunod.- G. Vosselman and H.-G. Maas, 2010, Airborne and Terrestrial Laser Scanning, CRC Press.

FIRST STEP PROJECT

Richard Benton, Marie-Christine Broillet, Antoine Guisan, Tadeusz Kawecki, Laurent Lehmann, Sanjiv Luther

TP	Obl	English	224
A	15		

TP	Obl	English	280
A	15		

TP	Obl	English	250
S	14/25		

TP	Obl	English	224
A	15		

TP	Obl	English	224
A	15		

TP	Obl	English	224
A	15		

N: Master

P: Practicals performed during the bachelor (molecular biology, genetics, biochemistry, bioinformatics)

O: - An initiation to the work of a scientist
- Conduct experimental work in research lab (wet bench or in silico)
- Interpretation of research results
- Implement basic principles in experimental design (e.g. include the appropriate controls, statistical significance of the results etc...)
- Present your experimental work in a written report which will be organized like a typical research article (intruduction, results, discussion, materials and methods)
- present your work orally (seminar style)

C: Perform laboratory work for about 12 weeks during the time when the student does not follow theoretical classes. This research project will typically be performed under the guidance of a PhD student or a post-doc from the host laboratory.

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MODULE 3

Courses / *Enseignements*	Hours per semester C	E	S	PW	Teaching Staff	ECTS	Limited nb of students
Compulsory Courses / *Enseignements obligatoires*							
Semester 2 (Spring) / *Semestre 2 (printemps)*							
Integrated course Mountain Ecosystems *Cours intégré écosystèmes de montagne*	28	-	-	-	**Guisan A.**	3	
Integrated Practical Work Mountain Ecosystems in the Alps *Travaux pratiques intégrés écosystèmes de montagne dans les Alpes*	-	-	-	52	**Guisan A.**	4	
Subtotal / *Sous-total*	28	0	0	52		7	
Optional Courses / *Enseignements optionnels* *							
Semester 2 or 4 (Spring) / *Semestre 2 ou 4 (printemps)*							
Aquatic ecosystems : glaciers, rivers and lakes (GSE) ** *Ecosystèmes aquatiques : glaciers, rivières et lacs*	48 CPW				**Perga M.-E., Lane S., Antoniazza G.**	5	
Field and laboratory methods (I) : The UNIL campus as a microcosm (GSE) *Méthodes de terrain et de laboratoire : le campus UNIL comme microcosme*	60 CPW				**Chèvre N., Vennemann T., Berg J.**	6	
Field and laboratory methods (II) : Alpine catchments (GSE, outside semester) *Méthodes de terrain et de laboratoire (II) : bassin versant alpin (GSE, hors semestre)*	50 CPW				**Perga M.-E., Lane S.**	5	
Mountain streams: ecological processes and management (GSE) ** *Rivières de montagne : écosystèmes aquatiques de la haute montagne*	24 CPW				**Lane S.**	3	
Watershed and river network modelling (GSE) *Modélisation des bassins versants et des réseaux fluviaux*	48 CPW				**Peleg N., Ruiz-Villanueva V.**	5	
Mountain streams: sediment management (field class) (GSE, outside semester, summer) *Rivières de montagne : gestion des sédiments (cours de terrain) (GSE, hors semestre, été)*	40 PW				**Lane S.**	3	
Applied Ecology *Ecologie appliquée*	14	-	-	36	**Pellet J.**	4	
Co-evolution, Mutualism, Parasitism *Co-évolution, mutualisme, parasitisme*	14	-	-	-	**Sanders I.**	2	
Current Problems in Conservation Biology *Problèmes actuels en biologie de la conservation*	14	14	-	-	**Wedekind C.**	4	10
Ecology of the Fishes of Switzerland *Ecologie des poissons de Suisse*	7		-	10	**Rubin J.-F.**	2	
Honeybee Ecology, Evolution and Conservation *Ecologie des abeilles, évolution et conservation*	14	-	-	-	**Dietemann V.**	2	
Phylogeny and Comparative Methods *Phylogénie et méthodes comparatives*	14	14	-	-	**Salamin N.**	4	
Spatial Modelling of Species and Biodiversity *Modélisation spatiale des espèces et de la biodiversité*	14	14	-	-	**Guisan A.**	4	
Behaviour, Economics and Evolution Lecture Series (HEC) *Séminaires BEE*	10	-	10	50	**Lehmann L.**, Santos-Pinto L.	6	
Interfaculty Seminar on the Environment (most in French, GSE) *Séminaire interfacultaire en environnement*	-	-	14	-	**Guisan A.**	2	
Scientific Communication - Scientific Hands-on Workshop Module (in French only) *Médiation scientifique - module atelier scientifique*	14	14	-	-	**Kaufmann A., Reymond P.,** Ducoulombier D.,Trouilloud S., Ythier M.	4	8
Seminars of the Department of Ecology and Evolution *Séminaires du Département Ecologie et Evolution*	-	-	10	-	**Kawecki T.**	2	
Sex, Ageing and Foraging Theory *Théories et modèles de l'évolution de la reproduction sexuée, la sénescence et la consommation de ressources*	9	-	-	9	**Mullon C.**	2	
The Evolution of Cooperation : from Genes to Learning and Culture *L'évolution de la coopération : des gènes à l'apprentissage et la culture*	22	-	-	-	**Lehmann L.**	3	
Semester 3 (Autumn) / *Semestre 3 (automne)*							
Environmental toxicology (GSE, MSc in Environm. Sci.) *Toxicologie environnementale*	30 CPW				**Chèvre N.**	3	
Soil and Water Chemistry (GSE, MSc in Environm. Sci.) *** *Chimie du sol et de l'eau*	40 CPW				**Keiluweit M.**	4	
Environmental time-series analysis (GSE, MSc in Environm. Sci.) *** *Traitement du signal et analyse de séries temporelles*	48 CPW				**Irving J.**	5	
Machine Learning for Earth and Environmental Sciences (GSE) *Apprentissage automatique pour les sciences de la terre et de l'environnement (GSE)*	48 CPW				**Beucler T.**	5	
Nature Conservation (in French, GSE, Master in Geography) *Conservation de la nature*	28 CSE + 16F				**Chanteloup L., Reynard E., Badman T., Walters G.**	4	
Remote sensing of Earth systems (GSE, MSc in Environm. Sci.) *** *Télédétection des systèmes terrestres*	48 CPW				**Mariethoz G., Antoniazza G., Lane S.**	5	
Biological Invasions *Invasions biologiques*	14	-	-	-	**Bertelsmeier C.**	2	
Advanced Data Analysis (MSc MLS) *Analyses de données : niveau avancé (MSc MLS)*	8	8	-	-	**Ciriello G.**	3	
Animal Communication and Parasitism *Communication animale et parasitisme*	14	-	-	-	**Christe P.**, Roulin A.	2	
Anthropogenic Effects on Wild Animals : Mechanisms and Fitness Consequences *Effets anthropogènes sur les animaux sauvages : Mécanismes et conséquences sur la fitness*	14	-	-	-	**Bize P.**	2	
Molecular Methods in Ecology and Evolution *Méthodes moléculaires en écologie et évolution*	18	-	-	42	**Sanders I.**, Fumagalli L., Salamin N.	6	
Phylogeography *Phylogéographie*	7	10	-	-	**Fumagalli L.**	2	
Population Genetics and Dynamics *Génétique et dynamique des populations*	9	20	-	-	**Goudet J.**	4	

Interdisciplinary courses marked in green
Disciplinary courses marked in pink

* - Before choosing a interdisciplinary optional course (marked in green), please check the "programme requirement" (prerequisites for the course) in the course description
- Students can choose optional courses not included in this study plan for a max. of 4 ECTS. They can also obtain a maximum of 6 ECTS for a professional internship outside of Unil. Both are subject to prior approval of the head of the Master and will require a sufficient proof of completion

** For the courses "Aquatic Ecosystems : Glaciers, Rivers and Lakes (GSE)" and "Mountain streams: ecological processes and management (GSE)", you can choose only one of the two

*** Only if the course was not already taken as part of Module 1 in Semester 1

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MODULE 3	Courses / *Enseignements*	Hours per semester C	E	S	PW	Teaching Staff	ECTS	Limited nb of students
	Optional Courses / *Enseignements optionnels* *							
	Optional Field Courses / *Etudes de terrain optionnelles* ***(Financial contribution by the student required)***							
	Drivers of Invertebrate Biodiversity along Altitudinal Gradients (Field course in the Alps) *Facteurs déterminant la biodiversité des invertébrés le long de gradients altitudinaux (stage de terrain dans les Alpes)*	6	-	-	80	**Schwander T.**	6	20
	Ecology and Evolution of the Mediterranean Flora *Ecologie et évolution de la flore méditerranéenne*	-	-	-	48	**Pannell J.**	4	14
	Total						**40**	

Disciplinary courses marked in pink

* Students can choose optional courses not included in this study plan for a max. of 4 ECTS. They can also obtain a maximum of 6 ECTS for a professional internship outside of Unil. Both are subject to prior approval of the head of the Master and will require a sufficient proof of completion

MODULE 4	Personal Research Project / *Projet de recherche personnel*	Hours per semester C	E	S	PW		ECTS
	Semesters 2 to 4 (Spring / Autumn) / *Semestres 2 à 4 (Printemps / Automne)*						
	Write a Review *Rédaction d'une revue*	4	2	-	-	Kawecki T., Director of the Master Research Project	5
	Master Research Project GEE *Travail de Master GEE*					Director of the Master Research Project	45

INTEGRATED COURSE MOUNTAIN ECOSYSTEMS

Antoine Guisan

C	Obl/Opt		English	28
S	1.5/3			

N: Master

P: none

O: To obtain a multidisciplinary knowledge basis on aspects of ecology & evolution of mountain ecosystems

C: General introduction to mountain environments Adaptations to marginal environments Reproductive systems along elevation Patterns of micro-organisms along elevation Biological invasions in mountains Impact of climate change on mountain biota - field observations and experiments Impact of climate change on mountain biota - spatial modelling Human-wild fauna conflicts in mountain regions

B: Donnée séparément pour chaque leçon.

I: Planning détaillé donné sur moodle aux étudiant.e.s inscrit.

INTEGRATED PRACTICAL WORK MOUNTAIN ECOSYSTEMS IN THE ALPS

Antoine Guisan

T	Obl/Opt	English	52
S	3/4		

N: Master

P: Having followed the integrated course "Mountain Ecosystems"

O: The objectives are four-fold:
- be able to carry out a small research project from beginning to end.
- Learn to work in interdisciplinary team: groups of 5 students from the FBM and FGSE (if possible at least one FGSE student per group).
- be able to efficiently and elegantly communicate your scientific findings (oral and written).
- learn how to carry ecological field work.

C: Two field retreats in Arolla (VS) - usually in May (2 days) and July (4.5 days)
First retreat to design a project and write a proposal
Second retreat to conduct the project in the field, and write a final report ("paper style")
Instructions on the two retreats' programs and the expected proposal and final report on moodle.
Bibliography:
Differents species identification field guides.
Bowman, W. D., and T. R. Seastedt, editors. 2001. Structure and Function of an Alpine Ecosystem : Niwot Ridge, Colorado. Oxford University Press Inc New York.
Nagy, l., and G. g. 2009. The biology of alpine habitats. Oxford University Press, Oxford.
Körner, C. 2003. Alpine plant life: Functional plant ecology of high mountain ecosystem. 2nd Edition edition. Springer, New York.
Ozenda, P. 1985. La végétation de la chaîne alpine dans l'espace montagnard européen. Masson, Paris.

B: Différents guides d'identification d'espèce sur le terrain.
Bowman, W. D., and T. R. Seastedt, editors. 2001. Structure and Function of an Alpine Ecosystem : Niwot Ridge, Colorado. Oxford University Press Inc New York.
Nagy, l., and G. g. 2009. The biology of alpine habitats. Oxford University Press, Oxford.
Körner, C. 2003. Alpine plant life: Functional plant ecology of high mountain ecosystem. 2nd Edition edition. Springer, New York.
Ozenda, P. 1985. La végétation de la chaîne alpine dans l'espace montagnard européen. Masson, Paris.

I: Info détaillées sur moodle pour étudiant.e.s inscrit.e.s

AQUATIC ECOSYSTEMS: GLACIERS, RIVERS, AND LAKES

Gilles Antoniazza, Stuart Lane, Marie-Elodie Perga

C/TP	Opt	English	48
P	5		

N: Master

P: Basic fluvial hydraulics (or equivalent) General ecology Statistical analysis of environmental Data

O: The objective of this course is to provide to the students a watershed-wide perspective on aquatic ecosystems and associated environmental issues, accounting for the ecological continuity of glaciers, rivers and lakes in the Alpine landscape. This course builds on preliminary knowledge in river hydrology and geomorphology to develop the ecological dimensions of river management. It also includes a full course in limnology blending the physical, biogeochemical and ecological aspects of lakes, emphasizing the necessity for such an integrative perspective to deal with current environmental challenges on Swiss lakes. The course is designed to favor hands-on in situ or in silico approaches of rivers and lakes. The course concludes with an introduction in how these principles are reflected in the Swiss Water Law as well as international comparisons.

C: The courses is divided into 2:
(1) Lakes and limnology, including lake ecology
(2) Rivers and ecology
The course finishes with a consideration of the relationship between this scientific understanding and policy, looking at the Swiss Water Law and also international comparisons.
The course comprises lectures and practical classes, as well as a small amount of fieldwork to support understanding. Specific training is also provided in certain key methods used by industry and regulators for biological water quality assessment.

B: Limnology, 3rd Edition
Lakes and River Ecosystems, R. Wetzel, 2001, Elsevier
Lakes: a very short introduction, W Vincent, 2018, Oxford University Press

FIELD AND LABORATORY METHODS (I): THE UNIL CAMPUS AS A MICROCOSM

Jasmine Berg, Nathalie Chèvre, Floriane Tisserand, Torsten Vennemann

TP	Opt	English	60
P	6		

N: Master

FIELD AND LABORATORY METHODS (II): ALPINE CATCHMENTS

Stuart Lane, Marie-Elodie Perga

T	Opt		English	50
P	5/6			

T			English	50
A				

N: Master

P: Aquatic ec

O: This field camp aims at training students to the application of classical and up-to-date technologies to the study of the hydrological, geomorphological, physical and ecological aspects of an alpine catchment.
Due to the large number of students, students are split in between a field camp on alpine streams (Arolla) and another on lakes from the Lexplore platform.

C: For the Lexplore Camp.
The camp alternates field work on the Lexplore platform, to analyses in the labs and hand-on work in classes.
The main objective of the camp is to train students for good practices in environmental data collection, from planning of the sampling design, to the basics principles of chemical or sensors-based measurements, the operations on-site, quality charts and sensors calibration and maintenance, mooring design, data curation and modelling.
Course structure
- Preparation of the field camp (in classroom). Specifications on the given missions, planning of required actions and measurements to be undertaken, budget and material. Protocols for chemical measurements in the lab, and technical specifications on sensors technologies.
- On the field and in the labs: use of sensors (temperatures, pressure, DO, CO2, YSI multiparameter probe; calibration, installation, data retrieval), field measurements (river flows, use of mutiparameter probes, water sampling, sediment sampling, dGPS, chemical and biological samples_chl a, DO by winkler's titration, alkalinity, pH, phosphorous concentrations by molybdate blue, microscopic analyses for zooplankton).
- Data curation and modelling (LakeMetabolizer) in classrooms
- Report: data analyses, literature, completion of the missions.
For the Arolla camp
Students will receive in high level training in two methods chosen from the following albeit with different emphases given your prior experience:
1. Continuous monitoring of river discharge.
2. Continuous monitoring of suspended load.
3. Use of biological sampling to determine mountain stream health.
4. Drone-based river corridor survey for land cover mapping.
5. Drone-based river corridor survey for measurement of erosion and deposition.
6. Grain-size characterization of the stream bed.
This training includes
a. Monitoring design (where, when, how often), protocols and standards
b. Choice of equipment, options, costs
c. Installation
d. Calibration data collection
e. Processing of acquired data including calibration relations, error quantification and propagation of error
Students will undertake (a) through (d) during the field camp; and work on (e) during the evenings at the field camp.

MOUNTAIN STREAMS: ECOLOGICAL PROCESSES AND MANAGEMENT

Stuart Lane

C/TP	Opt	English	24
P	3		

N: Master

P: A background in fluvial hydraulics is a help.

O: The aim of this course is to introduce students to the relationship between the physical environment of glaciers and mountain streams and the ecosystems that form there; and the implication for the management of mountain freshwater systems.

C: The course covers

1. The conceptualization of glaciers and rivers within the continuum of ecosystems that form from source to sink in river systems and the specificities that result.
2. Glacial ecosystems and the kinds of glacial life, on ice and under ice
3. The downstream influences of snow-melt and glacier-melt in terms of hydrology, sediment transport, stream temperature and nutrients
4. The types of mountain streams that result and the autogenic processes that shape the availability of stream habitat in space and its perturbation through time
5. The physical and chemical environment of mountain streams in terms of hydraulics, sediment, light, temperature, oxygen, nutrients
6. Primary production and food webs in mountain streams
7. Biogeochemical cycles and fluxes of matter
8. Connections between rivers and lakes in the continuity of mountain streams from sources to sinks
9. Proglacial ecosystems
10. The management of mountain streams (flow regime, sediment regime, organic matter regime); kinds of interventions; application in CH (the Swiss Water Law) in comparison with other countries ("nationalized" approaches like the EU Water Framework Directive; "commodified" approaches like the US stream mitigation banks); restoring mountain streams

WATERSHED AND RIVER NETWORK MODELLING

Nadav Peleg

C/TP	Opt		English	24
P	5			

N: Master

O: 1. To familiarize students with hydro-morphological modeling concepts (including parameter calibration, model validation, sensitivity tests, and uncertainty analysis).
2. To provide theoretical and practical capabilities of model development for hydro-morphological systems and a range of catchment- and river-scale processes.

C: 1. Advanced topographic and morphometric analyses on digital elevation models (DEMs):
- Watershed as a landscape unit: flow characteristics and land surface parameters (e.g., flow direction, flow accumulation, topographic wetness index, terrain roughness, stream power index).
- River network analysis: topological and hierarchical analysis (e.g., stream order, gradient, stream power, sinuosity).

2. Geospatial and climate data for hydrology:
- Land use, soil types, geology, Hydrological Response Units (HRU) definition, measurement of climate data (rainfall, temperature) in time and space.
- Spatial interpolation of weather radar, satellite data, and climate reanalysis data.

3. Introduction to hydrological modeling:
- Conceptual hydrological models.
- Model calibration, validation, sensitivity, and uncertainty.
- Distributed physically-based hydrological models and global distributed models.

4. Modeling hydrological responses to climate and land-use changes:
- Climate models, climate scenarios, land-use changes.

5. Fluvial systems:
- Watershed-scale erosion and sediment transport processes.
- Introduction to landscape hydro-geomorphic modeling (e.g., cellular automata models, gridded landscape evolution models).

MOUNTAIN STREAMS; SEDIMENT MANAGEMENT

Stuart Lane

C/TP	Opt	French	40
A	3		

N: Master

APPLIED ECOLOGY

Jérôme Pellet

C	Opt	English	14
S	3/4		

TP	Opt	English	36
S			

N: Master

P: BSc level in biology, including ecology

O: Applied ecology is a young crisis discipline undergoing a major effectiveness revolution. In most situations, urgent action is necessary, even in the absence of reliable information. How do we gather sound ecological information? How do we use it to plan natural communities conservation? In the process of answering these questions, wildlife ecologists often realize that research and practice are just two sides of the same coin.
After this lecture, students are able to understand the underlying concept of evidence-based conservation and adaptive management. They have applied the concepts in several different conservation settings.

C: The goal of the course is to teach students some of the skills they will need as evidence-based conservationists. Practical examples will be drawn from various ecosystems, communities and species. The course will revolve around the stages of adaptive management:
monitoring ecological resources, monitoring occupancy and abundance
research syntheses (systematic reviews and meta-analyses)
ecological triage (systematic conservation planning and red lists)
natural communities conservation planning and legislative context.
Field-based case studies will provide students an opportunity to apply and discuss some of the principles illustrated in the course. Practical work will include meeting with practitioners, discussing and analyzing their approach and methods through the prism of adaptive management.
« There is no such thing as a special category of science called applied science; there is science and its applications, which are related to one another as the fruit is related to the tree that has borne it. » Louis Pasteur

CO-EVOLUTION, MUTUALISM AND PARASITISM

Ian Sanders

C	Opt		English	14
S	1.5/2			

N: Master

P: Must understand english and be prepared to give presentations

O: To understand the evolutionary consequences of organisms living together in mutualism or parasitism and how to investigate it experimentally

C: The course comprises some introductory talks given by me about concepts in co-evolution and theoretical frameworks for studying co-evolution. Afterwards, students give presentations on chosen key publications in this field and the group discusses these subjects after the presentations.

B: : All bibliography is made availble in pdf format before the course begins. For an example of the publications discussed you can find last years publications in my docunil public folder.

CURRENT PROBLEMS IN CONSERVATION BIOLOGY

Claus Wedekind

C	Opt	English	14
S	3/4		

E	Opt	English	14
S			

N: Master

P: Lectures, discussions, and proposal writing in English.

O: Introduction into
- some important problems of conservation biology
- funding opportunities for conservation projects
- the planning, writing, and reviewing of grant proposals in the context of the course

Own ideas shall be developed, presented and discussed in class.

C: Some current research topics within the field of conservation biology will be further introduced in lectures, potentially also guest lectures, and discussions in class. Each student then develops an own idea of a research project within these topics. After an introduction into funding agencies and the planning and writing of grant proposals, each student (or groups of two) write(s) up an own proposal and present(s) it to the class. The proposals of colleagues will then be peer-reviewed after an introduction into peer-reviewing of grant proposals.
Class size restricted to 10 students.

ECOLOGY OF THE FISHES OF SWITZERLAND

Jean-François Rubin

C	Opt	English	7
S	1.5/2		

TP	Opt	English	10
S			

N: Master

P: none

O: Recognize the different habitats and species
Know the biology of the principal species
Identify the problems linked to the management of these habitats and species

C: Generalities on water
Lakes
Watercourses
Plankton and plants
Systematic of fish
Anatomy of fish
The fish of Switzerland

HONEYBEE ECOLOGY, EVOLUTION AND CONSERVATION

Vincent Dietemann

C	Opt	English	14
S	1.5/2		

N: Master

P: none

O: At the end of this series of courses, students will be able to describe the complexity of social organisation in honey bees. They will have acquired advanced knowledge of the mechanisms underlying the ability of honeybees to adapt to natural and human-induced changes, as well as the limits to this ability to adapt. In the light of this knowledge, students will be able to analyse, evaluate and critique the quality of information available in the media and scientific literature on this highly socio-economic organism. This critical sense can also be extended to other themes and organisms. Through the proposed examination, students will practice writing clear and succinct answers to questions that require the collation and logical organisation of information from multiple sources.

C: Since honeybees are economically important insects, they have been studied early in history and the knowledge we possess about them is greater than for any other social insect species. Our understanding of the honeybee reveals the complex organisation reached by insects when they form societies. This series of lectures will present some aspects of this complexity that will be replaced within its evolutionary context. Various aspects of honeybee ecology and evolution, including geophylogeny, biology, reproduction at individual and colony level, division of labour, communication, pathogens will be presented. As the honey bee is an insect of high economic value, we will also look at the socio-economic aspects that influence its biology and evolution.

After a general introduction of this model species describing the diversity and biogeography of the taxon, we will dissect the communication abilities of European honeybees and compare it with related Asian species. We will see how this communication is used to organise foraging tasks sustaining colony growth. Honeybee health is a current concern and we will review the pathogens affecting them and comment the role of humans in their spread and control in an evolutionary context. Since honeybee stocks and wild populations are experiencing decreases in some regions of the world, we will see what economical losses could occur and some conservation projects to invert the trend will be put in context.

B: Seeley T, 1985. Honeybee Ecology. Princeton University Press.
Seeley T, 1995. The wisdom of the hive. Harvard University Press.
Moritz RFA, Southwick EE, 1992. Bees are superorganisms. Spiringer Verlag
Oldroyd B, Wongsiri S, 2006. Asian Honey Bees. Harvard University Press.
Koeniger N, Koeniger G, Tingek S, 2010.Honey Bees of Borneo. Natural History Publications
Winston ML, 1987. The Biology of the honey bee. Harvard University press.

PHYLOGENY AND COMPARATIVE METHODS

Nicolas Salamin

C	Opt		English	14
S	3/4			

E	Opt		English	14
S				

N: Master

P: none

O: Phylogenetic reconstruction methods and their application in evolutionary biology. To know and understand phylogenetic reconstruction methods in order to test the processes leading to genes and organisms evolution.

C: The subjects will be presented during lectures as well as practicals.
I. Reconstruction methods
- What is a phylogenetic tree and how to interpret it?
- Tree reconstruction:
a) optimisation criteria and models of evolution
b) search for the optimum tree
c) Bayesian methods
- Can we trust the inferred tree?
II. Uses for phylogenetic trees
- Detecting positive selection in a coding gene
- Testing coevolution and cospeciation
- Macroevolution:
a) dating evolutionary events
b) tempo and mode of evolution
c) testing for key innovations
- Phylogeny and conservation

B: Felsenstein, J. 2003. Inferring phylogenies. Sinauer Associates.
Page, R. 2003. Tangled trees: Phylogeny, cospeciation, and coevolution. University of Chicago Press.
Purvis, A., Gittleman, J.L. and Brooks, T. 2005. Phylogeny and conservation. Cambridge University Press.
Swofford, D.L., Olsen, G.K., Waddell, P.J. and Hillis, D.M. 1996. Phylogeny reconstruction. Pages 407-514 In Molecular Systematics (D.M. Hillis, C. Moritz, B.K. Mable, eds.). Sinauer Associates.
Yang, Z.H. 2006. Computational Molecular Evolution. Oxford University Press.

I: http://www.unil.ch/phylo/teaching/pmc.html

SPATIAL MODELLING OF SPECIES AND BIODIVERSITY

Antoine Guisan

C	Opt		English	14
S	3/4			

E	Opt		English	14
S				

N: Master

P: If possible, course 'Spatial Analyses & GIS' (ANSPAT) in 1st semester of the Master (not strictly required).

O: Species distribution models (SDMs) are increasingly important in ecology and conservation biology. This course proposes an introduction to these models and related concepts and methods. Overview of the main steps of model building. Advantages and limitations. Applications to various domains (climate change, invasions, rare species, ...).

C: Chap. 1. Introduction to species' niche & distributions, and related models. Theory and principles behind these models. Competition and disperal limitations. Types of response variables, main predictive modelling approaches, field sampling design, from predicting species distributions to predicting communities.
Chap. 2. Model calibration. Presence-only versus presence-absence data, statistical theory and methods for presence-only data, regressions and classifications for presence-absence, ensemble modelling and forecasting.
Chap. 3. Model evaluation. Internal versus external evaluation. Data and metrics for evaluation. Crossvalidation, jackknife, bootstrap, uncertainties.
Chap. 4. Assumptions behind these models. Pseudo-equilibrium, niche conservatism, niche completeness, realized niche, and other postulates.

B: Guisan, A. & Zimmermann, N.E. (2000). Predictive habitat distribution models in ecology. Ecological Modelling 135(2-3): 147-186.
Guisan A, Thuiller W (2005) Predicting species distribution: offering more than simple habitat models. Ecology Letters, 8, 993-1009.
Guisan et al. (2013) Predicting species distributions for conservation decisions. Ecology Letters 16: 1424-1435.

I: http://www.unil.ch/ecospat

BEHAVIOUR, ECONOMICS AND EVOLUTION LECTURE SERIES

Laurent Lehmann

C	Obl/Opt	English	10
S	6		

S	Obl/Opt	English	10
S			

TP	Obl/Opt	English	50
S			

N: Master

INTERFACULTY SEMINAR ON THE ENVIRONMENT

Antoine Guisan, Pierre-Louis Rey

S	Opt	French	18
S	2		

N: Master

P: None

O: To give students a deep understanding of an environmental issue, animated for the most part through contributions from external visitors to UNIL.

C: Conferences are in french.

B: Précisé par les intervenant.e.s de semaine en semaine

I: https://www.unil.ch/gse/sie

SCIENTIFIC COMMUNICATION - SCIENTIFIC HANDS-ON WORKSHOP MODULE

Alain Kaufmann, Philippe Reymond

C	Opt	French	14
S	3/4		

E	Opt	French	14
S			

N: Master

SEMINARS OF THE DEPARTMENT OF ECOLOGY AND EVOLUTION

Tadeusz Kawecki

S	Obl/Opt	English	10
A S	2		

N: Master

P: All seminars and discussions are in English

O: Learn about the current research of other groups and meet international experts.

C: International experts present their research and answer to questions in public.

SEX, AGEING AND FORAGING THEORY

Charles Mullon

TP	Opt	English	9
S			

C	Opt	English	9
S	1.5/2		

N: Master

P: Ability to program in R or other languages.

O: Introduction to theoretical principles and modelling approaches to fundamental problems in evolutionary ecology.

Understand the biological factors that influence the evolution of ageing, sex, and resource consumption.

Learn to conceptualise a biological problem and analyse it quantiatively.

Introduction to individual-based simulations.

C: We explore the evolution of sexual reproduction, ageing and resource consumption, through three big questions:

<p id="yui_3_17_2_1_1674222015810_171">1. Why do we age? <p id="yui_3_17_2_1_1674222015810_199">2. Why do we reproduce sexually?
3. How should we consume resources?

We look at these questions through mathematical and computational modelling. In addition to core concepts of evolutionary ecology, students thus learn how to formalize a theoretical model, implement it in a computer program (e.g. R, C or Python) and analyse its output.

THE EVOLUTION OF COOPERATION : FROM GENES TO LEARNING AND CULTURE

Laurent Lehmann

C	Obl/Opt	English	22
S	3		

N: Master

O: What makes us such a unique species, able to cooperate in large-scale societies, organize social interactions, and dominate ecologically the Earth? The main goal of this course is to provide the foundations of social evolution, which consists of two main ingredients in humans: cooperation and cumulative cultural evolution. On one side, the course will thus focus on studying the main forces favoring and maintaining cooperation (mutually beneficial interactions, altruism) and conflict (cheating, malevolence, warfare) in group-structured populations. On the other side, we will study the forces behind cultural evolution, where behavior in interactions depends on genetic determinants, social learning, and individual learning ("gene-culture coevolution"). This will allow discussing the major steps in human social organization evolution, from primate autarky to division of labor in large-scale societies.

C: The course will be composed of five main parts and more focused on human behavior than the "Ecology and Evolution" class on which it builds:
(1) Cooperation and conflict in well-mixed populations. Here, we will study the evolution of cooperation (and cheating) in well-mixed population (no division into groups). We will study the standard one-shot social dilemmas illustrating the tension between self-interest and group-interest, like the prisoner's dilemma and the stag-hunt game. We will then investigate various settings of repeated interactions, where reputation dynamics between individuals are crucial to sustain long-term relationships.
(2) Cooperation and conflict in group-structured population. Here, we will study the forces shaping cooperation when interactions occur in group-structured populations (the rule in humans), and where the localization of the social interactions generates in the same time novel incentives to cooperate and novel incentives for spiteful behavior. We will also consider conflicts between groups and study warfare in small-scale hunter-gather societies.
(3) Social learning and gene-culture coevolutionary theory. Here, we will study the main modes of social learning ("cultural transmission"), which underlies cumulative cultural evolution that is the main determinant of the human lineage ecological success. We will also study gene-culture coevolution and how social learning impacts the dynamics of cooperation within groups.
(4) Individual learning and preferences. Here, we will discuss the main modes of individual learning that allow individuals to learn information about the relevant behavior to express on their own (e.g., trial-and error learning and related decision heuristics, maximizing behavior). We will investigate the conditions under which evolution may and may not lead individuals to become equipped with goal functions ("utility maximization behavior").
(5) Major transition from small to large-scale societies. Here, we will discuss the main evolutionary steps that took the human lineage in a 6 million year long co-evolutionary gene-culture ride from self reliant primate social organizations ("autarky") to large scale societies with extreme division of labor ("catallaxy"). This transition involved a zizag path from dominance, to egalitarianism, to inequality again.

ENVIRONMENTAL TOXICOLOGY

Nathalie Chèvre

C/TP	Opt	English	30
A	2/3		

N: Master

P: Ecotoxicology

Aquatic Chemistry

General Geochemistry

O: This course is required for students completing the Masters in Environmental sciences option Aquatic sciences. This course focuses on methods and models used for environmental risk assessment of chemicals, as single compound or in mixture.

TEACHING OBJECTIVES

- o Teach major approaches used in risk assessment
- o Expose you to a variety of tools to analyze environmental problems from the perspective of ecotoxicology
- o Help you become autonomous

LEARNING OBJECTIVES

- o To become proficient with analysis and modeling of ecotoxicological data
- o To understand risk assessment approaches
- o To obtain insight on controversies surrounding chemical risk assessment

C: **PROGRAM**
Introduction
Effects data
Tests with daphnids
QSAR
Biomarkers
Risk assessment
Single substance and mixture risk assessment
Single substance and mixture risk assessment
Complex samples
In situ measurements
Human toxicology
Human toxicology, effects of endocrine disrupters
Controversy analysis

B: Environmental Modeling (1996) Schnoor, Wiley Intersciences.
Principles and Applications of Aquatic Chemistry (1993) Morel and Hering, Wiley.
Geochemistry, Groundwater and Pollution (2009) Appelo and Postman, CRC Press.
Encyclopedia of aquatic ecotoxicology; 2 volumes A-G et H-Z. (2013). Frérard JF., Blaise C., eds. Springer.
Fundamentals of ecotoxicology. 3rd ed (2010) Newman M. C., Lewis Publishers.
Risk assessment of chemicals: an introduction (2007). Van Leeuwen C. J., Vermeire T. G., eds, Springer.

SOIL AND WATER CHEMISTRY

Marco Keiluweit

C/E	Opt		French	39
A	4			

N: Master

ENVIRONMENTAL TIME-SERIES ANALYSIS

James Irving

C/TP	Opt	4	English	48
A	5			

N: Master

O: Ce cours fournit une introduction à l'analyse des séries temporelles et au traitement du signal pour les sciences de l'environnement. Les sujets à couvrir, dans le contexte des exemples environnementaux pertinents, comprennent l'analyse linéaire des systèmes et des signaux, la convolution, la transformée de Fourier, l'auto-corrélation et la corrélation croisée, le filtrage, la conception des filtres, l'échantillonnage et la reconstruction du signal, l'estimation spectrale, et l'analyse temps-fréquence. Les concepts appris lors des cours seront renforcés par des exercices informatiques.

MACHINE LEARNING FOR EARTH AND ENVIRONMENTAL SCIENCES

Tom Beucler

C/TP	Opt	English	48
A	5		

N: Master

P: - Basic knowledge of Python

- Interest in Earth and environmental sciences

O: Full English syllabus (with links) at https://wp.unil.ch/dawn/teaching/#ML_EES.
In this 8-week hands-on course, we will introduce common ML algorithms in the context of their application in environmental science and engineering. By the end of this course, you should be able to:

1. Name common ML algorithms (listed in Section 2 of the syllabus) and summarize their advantages and limitations, especially in the context of environmental science,

2. Implement them in Python (mostly using the Numpy, Scikit-Learn, Keras, and Tensorflow libraries in Google Collab notebooks),

3. Know from experience which algorithms are most appropriate for environmental applications you are passionate about (e.g., your Masters thesis).

C: Last updated on August 28, 2022; please consult https://wp.unil.ch/dawn/teaching/#ML_EES and select the appropriate semester for the most up-to-date information.

- Week 1-2: Linear/Logistic Regression for Classification/Regression & Statistical Forecasting
- Week 2-3: Decision Trees/Random Forests/SVMs & Environmental Risk Analysis
- Week 3-4: Unsupervised Learning for Clustering/Dimensionality Reduction & Environmental Complexity
- Week 4-5: Artificial Neural Networks & Surrogate Modeling
- Week 5-6: Generative Modeling: From Uncertainty Quantification to Stochastic Downscaling
- Week 6-7: Convolutional Neural Networks & Remote Sensing
- Week 7: First In-Class Presentation
- Week 7-8: Graph Neural Networks & Interconnected Systems
- Week 8-9: Explainable Artificial Intelligence & Understanding/Communicating Predictions
- Week 9-10: Hybrid Modeling & Knowledge-Guided Learning
- Week 10-12: Office Hours for Final Projects, In-Class Peer-Review and In-Class Presentations

Possible overview of student-chosen related topics not covered in class that may be relevant to final projects: Bayesian inference, Causal discovery, Data ethics, Recurrent Neural Networks, Reinforcement Learning, Symbolic Regression.

In-class peer review: Each class member submits the draft of their final project for review and reviews 3 drafts from peers.

B: 1. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition" by Aurélien Géron (https://www.oreilly.com/library/view/hands-on-machine-learning/9781492032632/)
2. "Deep Learning with Python, 2nd Edition" by Francois Chollet (https://www.manning.com/books/deep-learning-with-python)

I: https://wp.unil.ch/dawn/teaching/#ML_EES

NATURE CONSERVATION

Tim Badman, Laine Chanteloup, Morgane Müller, Emmanuel Reynard, Gretchen Walters

C/TP	Opt	2	French
A	4		

N: Master

O: In November 2019, the University of Lausanne and the IUCN signed a partnership agreement aimed at intensifying their exchanges around research work and its applications on the planet's environmental concerns. This course is a concrete application of this partnership involving both various researchers from Unil and IUCN professionals.
A convention is also being set up between the University of Lausanne and the Lavaux World Heritage Association to strengthen the scientific knowledge carried out in this protected area. This course aims to get better acquainted with this site and the conservation challenges it faces.
The objective of this course is to bring elements of reflection and analysis to students concerning contemporary debates around the conservation and protection of nature. This course reviews the definitions as well as the historical and cultural aspects of nature conservation and the implementation of different protected areas around the world. It also addresses through various examples and case studies the current management issues in nature conservation. This course-seminar includes two field trips with meetings of IUCN professionals.

C:
- Introduction to Nature Conservation
- Protected areas and landscape governance
- Conservation and management issues
- Management effectiveness, World Heritage, geoparks, biosphere reserves and Ramsar.
- Fieldtrip to Lavaux Unesco site
- Hunting, protected areas and conservation
- Fieldtrip to IUCN center
- Conservation by indigenous peoples and local communities
- Conservation and Education

B:

- Adams WM (2004) Against extinction: the story of conservation. Earthscan, London; Sterling, VA
- Bory Stéphanie et Gábor Baranyai (dir), 2016, Les espaces naturels protégés sont-ils nécessaires?, Pessac Gironde, Presses univ de Bordeaux, Dynamiques environnementales 35, 235 p.
- Depraz Samuel, 2008, Géographie des espaces naturels protégés genèse, principes et enjeux territoriaux, Paris, A. Colin, Collection U. Géographie, 1 p.
- Héritier, Stéphane et Lionel Laslaz (dir), 2008, Les parcs nationaux dans le monde: protection, gestion et développement durable, Paris, Ellipses, Carrefours. Les dossiers, 312 p.
- Larrère, Raphaël. « Le conflit entre les chasseurs et les protecteurs de la nature ». La Ricerca Folklorica, no 48 (2003): 45 51.https://doi.org/10.2307/1480073.
- Laslaz, Lionel (dir.), 2012, Atlas mondial des espaces protégés: les sociétés face à la nature, Paris, EdAutrement, Autrement. Collection Atlas/Monde, 96 p.
- Laslaz Lionel, C. Gauchon, M. Duval, S. Héritier (dir.),, 2014, Les espaces protégés: entre conflits et acceptation, Paris, Belin, Mappemonde, 431 p.
- Mollett, Sharlene, and Thembela Kepe, eds. 2018. Land Rights, Biodiversity Conservation and Justice: Rethinking Parks and People. Routledge Studies in Sustainable Development. Abingdon, Oxon; New York, NY: Routledge, Taylor & Francis Group.

REMOTE SENSING OF EARTH SYSTEMS

Gilles Antoniazza, Stuart Lane, Grégoire Mariéthoz

C/TP	Opt	4	English	48
A	5			

N: Master

P: Bases in remote sensing, use of Matlab and/or other scripting languages

O: The aim of this course is to provide advanced knowledge of some specific methods used in remote sensing. This will include retrieval and processing of satellite data, data acquisition techniques such as photogrammetry, Structure-From-Motion and methods used as well as computer-aided processing and visualization of remote sensing data.

C: At the end of this course, students will: - Be able to locate and download satellite imagery, and apply treatment to such images in order to extract information; - Be familiar with platforms such as USGS GLOVIS and Google Earth Engine; - Be able to use advanced software tools such as the Matlab Image Processing Toolbox for the processing of remote sensing data; - Be able to apply standard methodologies such as classification, pansharpening, interpolation, edge detection or filters, among others; - Have the ability to apply and understand the principles of photogrammetry.

B: - T. Lillesand, R. Kiefer, J. Chipman, 2015, Remote Sensing and Image Interpretation, Wiley. - J. Campbell & R. Whyne, 2011, Introduction to Remote Sensing, Guilford Press.- M-C Girard et C-M Girard, 2010, Traitement des données de télédétection, Dunod.- G. Vosselman and H.-G. Maas, 2010, Airborne and Terrestrial Laser Scanning, CRC Press.

ADVANCED DATA ANALYSIS

Giovanni Ciriello

C	Obl/Opt	English	8
A	2.5/3		

E	Obl/Opt	English	8
A			

N: Master

P: You must have attended the first data analysis course, or convince me that you are competent at basic statistical analyses.

O: This course follow-up on the Data Analysis course to introduce advanced statistical and algorithmic approaches tailored to the analysis of high-dimensional data.

C: In this course we will cover:

1. Penalized regression models

2. Clustering analyses

3. Dimensionality reduction techniques

4. Introduction to deep learning

ANIMAL COMMUNICATION AND PARASITISM

Philippe Christe

C	Opt	English	14
A	1.5/2		

N: Master

P: None

O: Across the animal kingdom, individuals of the same species differ in their propensity to take risks, and explore new environments, and to be active, aggressive or sociable. Individual differences in behaviour that are consistent through time and across contexts are coined 'personalities', 'behavioural syndromes' or 'temperaments'. The terminology of personality is not a mere fashionable label of something usually studied by behavioural ecologists, but useful to conceptualize the common phenomenon that individuals differ markedly and consistently in their behavioural phenotypes across ecological and social contexts. The notion of personality implies that suites of behaviours are correlated within individuals and hence individuals are less flexible than would be expected under optimality models. In this course, I propose to study personality from an evolutionary point of view and also the evolution of language.

C: This lecture is interactive and illustrated by recent research articles.
7h will be given by A. Roulin and 7h by P. Christe

B: Réale, D., Reader, S.M., Sol, D., McDougall, P.T. & Dingemanse, N.J. (2007). Integrating animal temperament within ecology and evolution. Biol. Rev., 82, 291-318.
Sih, A., Bell, A.M., Johnson, J.C. & Ziemba, R.E. (2004). Behavioral syndromes: an integrative overview. Q. Rev. Biol., 79, 241-277.
Journaux scientifiques figurant sur internet (http://perunil.unil.ch/perunil/periodiques/).

I: Aucune

ANTHROPOGENIC EFFECTS ON WILD ANIMALS : MECHANISMS AND FITNESS CONSEQUENCES

C	Opt		French	14
A	2			

N: Master

MOLECULAR METHODS IN ECOLOGY AND EVOLUTION

Luca Fumagalli, Ian Sanders

C	Obl/Opt	English	18
A	3/3.5/5/6		

TP	Obl/Opt	English	42
A			

N: Master

O: The objective of this course is to learn the relevant molecular tools that are currently used in ecology, evolutionary and conservation biology research and understand why and when to apply them.

C: This course covers the reasons why molecular genetics is a necessary tool in many ecology, evolution and conservation biology projects. We study its uses and then look at at selection of techniques, particularly for looking at polymorphism, that are not traditionally taught in molecular cell biology courses. Man of the techniques can only be learnt in the classroom as there is not enough time in a week to practically learn all useful techniques. Therefore, the associated laboratory class cover some of the fast techniques that are useful for studying polymorphisms in populations.

B: The course is mostly based on publications in international journals rather than one specific book. The publications are made available in pdf format at the beginning of the course.

PHYLOGEOGRAPHY

Luca Fumagalli

C	Opt	English	7
A	1.5/2		

E	Opt	English	10
A			

N: Master

O: 1) Course
Study of the historical processes (population expansions, bottlenecks, vicariance and migration) responsible for the current geographic distribution of genealogical lineages.
2) TPs
Analysis and interpretation of phylogeographic data with the help of several softwares.

C: 1) Phylogeography: definition and historical backgrounds
2) Animal and plant molecular markers
3) Distribution area
4) Gene tree/species tree
5) Molecular clocks
6) Coalescence
7) Mismatch distribution
8) Phylogenetic trees and networks
9) Phylogeographic patterns
10) Comparative phylogeography
11) Phylogeography and conservation
12) Phylogeography and genomics.

B: Avise JC. 2000. Phylogeography. Harvard University Press.

POPULATION GENETICS AND DYNAMICS

Jérôme Goudet

C	Obl/Opt	English	9
A	1.5/4		

E	Obl/Opt	English	20
A			

N: Master

P: A good grasp of the principles of population genetics and population dynamics (i.e. at least an introductory course in both)

O: Gain an understanding of how genetics and genomics interact with demographic and selective processes, with a particular emphasis on inbreeding depression and genetic rescue
website:
http://www2.unil.ch/popgen/teaching/PGD21

C: In the first part of the course, selected papers from the
recent literature are presented by students and discussed in a
journal club format.
In the second part, in groups of 2-3 students you will use
computer simulations and the quantiNemo program to investigate questions such as:
-When and how can a small population purge deleterious alleles?
-How can we quantify Inbreeding Depression?
-is neutral diversity a good proxy for the health status of a population?

I: http://www2.unil.ch/popgen/teaching/PGD21/

DRIVERS OF INVERTEBRATE BIODIVERSITY ALONG ALTITUDINAL GRADIENTS

Tanja Schwander

T	Opt	English	80
S			

C	Opt	English	6
S	3/6		

N: Master

P: Program requirement: Financial participation required by the student (approximately 480.-)

O: During this field course, we study different invertebrate taxa (mainly insects and gastropods) to understand the factors driving biodiversity and community composition, as well as the evolution of different life cycles under diverse ecological conditions in the Swiss Alps/Prealps.

C: Course content: - Introductory lectures - Excursions and group field work: analysis of community composition and biodiversity in various habitats - Personal experiments (experimental design, data collection & analysis, presentation of results) - Discussion of scientific papers

ECOLOGY AND EVOLUTION OF THE MEDITERRANEAN FLORA

John Pannell

T	Opt	French	48
S	2/4		

N: Master

P: Financial participation required by the student.

WRITE A REVIEW

Tadeusz Kawecki

C	Obl	French	4
S	5		

E	Obl	French	2
S			

N: Master