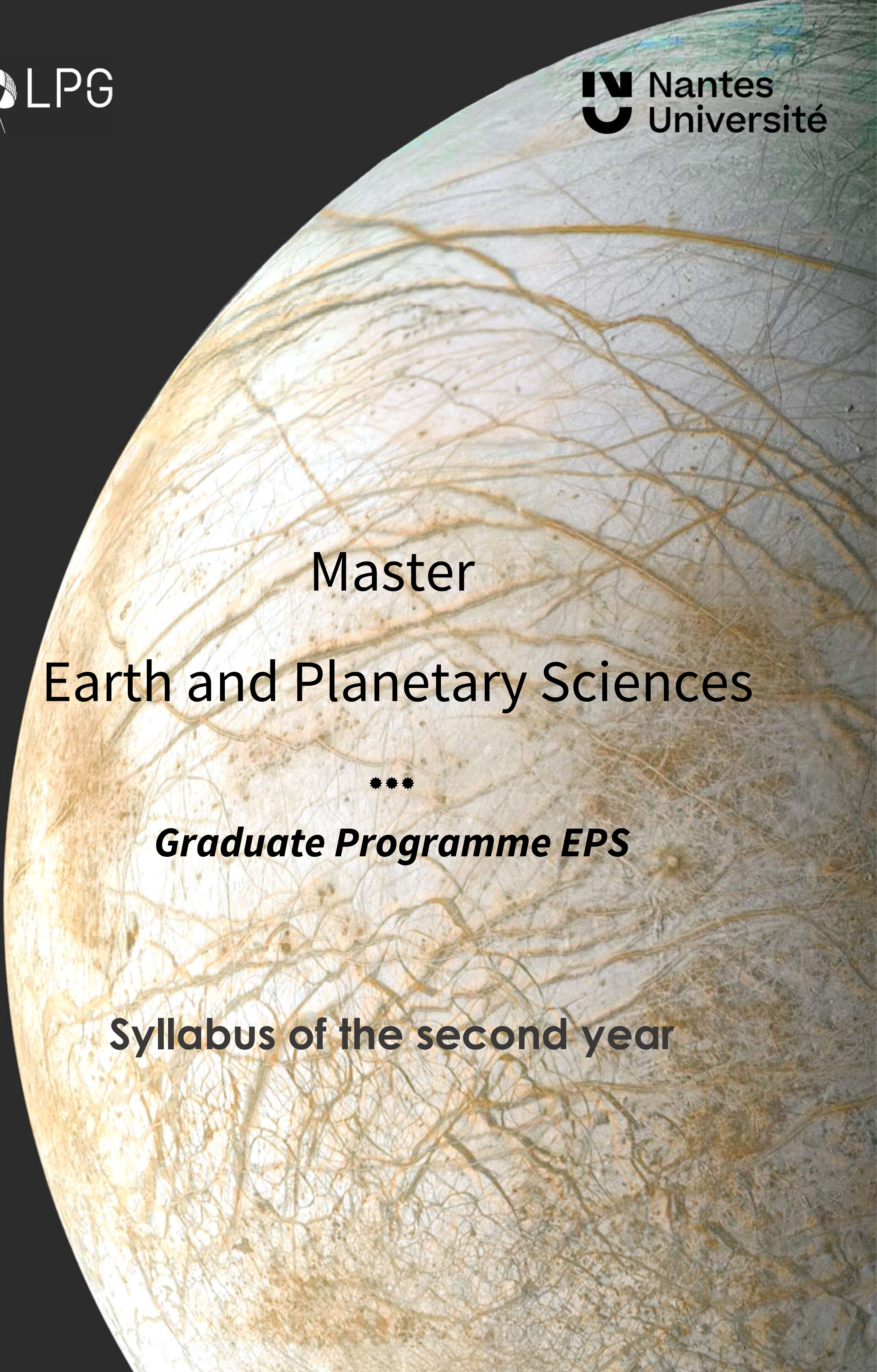


Master

Earth and Planetary Sciences

***

Graduate Programme EPS

Syllabus of the second year

Contentss

General Overview

INTRODUCTION

Our Master's degree in Earth and Planetary Sciences aims to train the next generation of geologists, planetologists and space exploration mission experts by offering a cutting-edge teaching programme and the opportunity to study in an international environment. This course will offer you a unique learning experience combining a theoretical approach, field experience and project-based teaching at the Laboratoire de Planétologie et Géosciences (LPG). The LPG is involved in space exploration programmes as a member of the international research and training consortium GeoPlaNet, comprising more than 20 institutional research partners worldwide. Throughout your studies, you will work with students and researchers from different countries and be introduced to the major international programmes of NASA and ESA.

Through our multidisciplinary approach, which draws on the latest knowledge in geosciences and planetary sciences, you will acquire cutting-edge knowledge and develop research skills from the Master's level onwards:
- Working in an international collaborative environment
- Analysing and interpreting multidisciplinary data using advanced techniques and digital tools.
- Communicating the latest advances in the field in a concise, academic manner.

Mastering these advanced techniques will give you a range of opportunities to pursue a career in academic or private entities linked to the geosciences and space exploration.

CAREERS OPPORTUNITY

Nearly half of the Master's students go on to study for a PhD, while the other half enter the job market directly in the R&D departments of large organisations or in research consultancies. They occupy positions such as :

- Data analysis engineer (remote sensing, mapping, simulation, etc.)
- Geophysics/geology engineer
- R&D engineer in space/laboratory instrumentation

After studying for a doctorate, they can also go on to positions such as :

- Researcher or teacher-researcher
- Scientific manager
- Project manager

PROGRAM LEADER ON MASTER 2 LEVEL

Yann MORIZET yann.morizet@univ-nantes.fr

Gabriel TOBIE gabriel.tobie@univ-nantes.fr

SKILLS BASED APPROACH

At the end of the course, students should be able to :

- ✓ Define and collect a corpus of geological or geophysical data in the field, in the laboratory, or through numerical simulations
- ✓ Contextualise the sample within its environment and test its representativeness
- ✓ Analyse, exploit and structure data from field observations, laboratory experiments or simulations, using descriptive statistical tools, taking into account uncertainties and biases
- ✓ Design a geological, theoretical or predictive model and test it
- ✓ Report one's results by positioning oneself in relation to a shared state of the art
- ✓ Promote scientific results and the proposed strategy, in writing and orally, in several languages, to a specialist audience, as well as to the general public
- ✓ Position oneself in a professional environment and collaborate within international and multidisciplinary teams
- ✓ Design and develop a project in geosciences or planetology

TEACHING LOCATIONS

UFR Sciences et Techniques
Campus Lombarderie
2, rue de la Houssinière
BP 92208
44322 Nantes Cedex 3

HOW TO APPLY FOR JOINING MASTER 2 EPS

Requirements:

Master 2 level is intended for students with a Master 1 or Bachelor 4 degree, preferentially in Earth and Planetary Science, and possibly Physics; Chemistry, Material Sciences or Mathematics.
Language requirement:

- TOIEC: minimum 800
- IELTS: 6.0
- TOEFL: 80

Or equivalent Graduate of a university in an English-speaking country

Application procedure :

The application procedure varies depending on several criteria, primarily your nationality and whether or not there is a partnership with your home university. All procedures are detailed on our website:
https://english.univ-nantes.fr/education/admissions/regular-admissions

For our selection, applicants will have to submit documents (and pass an interview if needed).

Basic documents are required:

- A CV written in English/French
- A cover letter written in English/French
- A recommendation letter if possible
- Transcripts

Scholarship and financial facilities

The French government covers a large part of the cost of higher education at university. While a year of university study costs an average of around €10,500 per year, the **tuition fees** payable by the student are **€254 for a year of a Master's degree** and €397 for a year of a PhD, to which must be added a student life contribution of around **€100**. Exchange students are **exempt from paying tuition fees**.

International students are given priority for a room or studio in a student residence during their first year of study. The cost of accommodation varies **from €260 for a room to €370 for a studio.**

A welcome grant of **1 500€** is available to foreign students enrolling at Nantes Université.

The internship lasts 5 to 6 months during the second year. Students doing internships in France are paid approximately €650 per month. Students who wish to do their internship abroad can receive a grant of €550 to €700 per month (depending on the destination country).

Students can also apply to excellence Eiffel scholarships (or other scholarships proposed by their ambassy to finance their study.

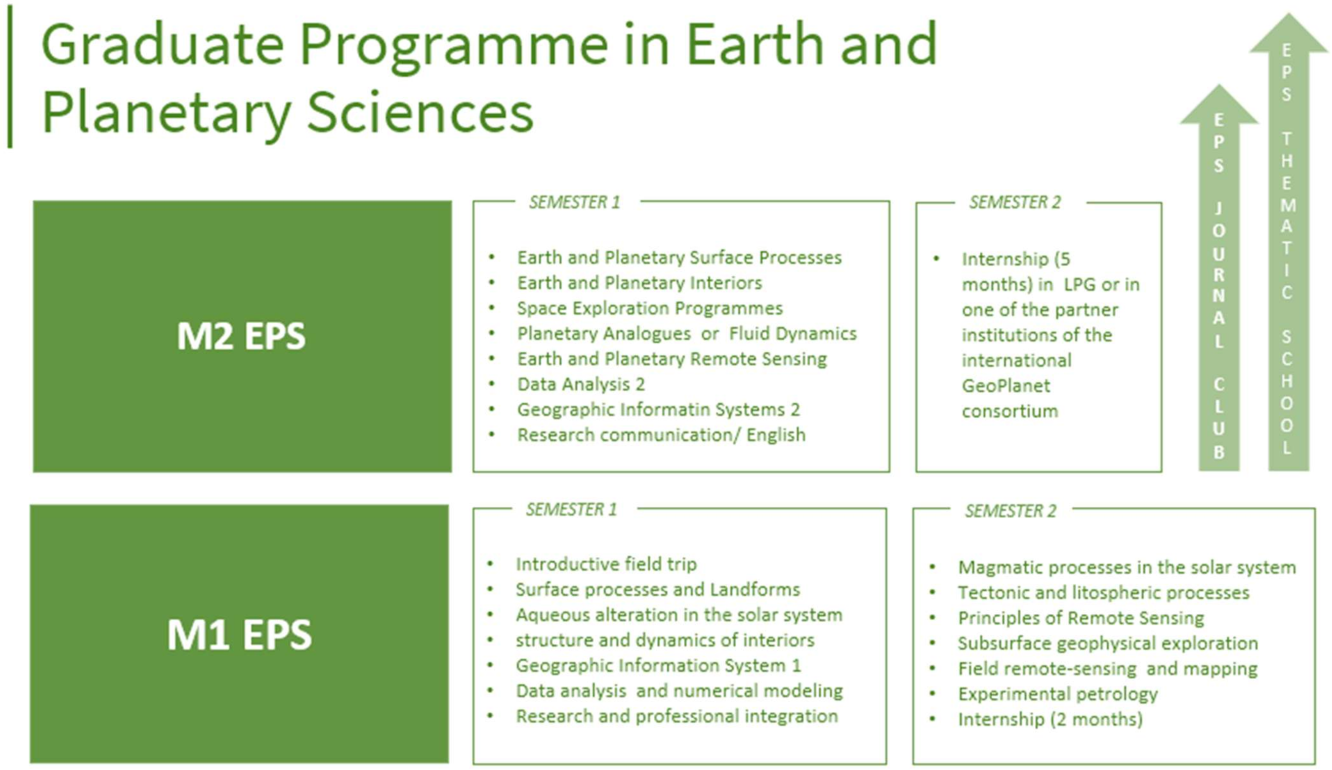
COURSE SCHEDULING

From September to December:	From January to August :
Lectures and practical training	5-month Internship

NB: Students enrolled in a foreign university may do an internship in one of our laboratories at any time of the year, subject to the constraints of their home institution.

PROGRAM STRUCTURE

The teaching program is organized in five teaching units detailed in next sections:



Space Exploration Programs

Affiliated TU: M2 EPS-S1	
Duration: 24h	Number of ECTS: 3
Year/semester: M2/S3	Language: English
Main teacher	Sabrina CARPY, Olivier VERHOEVEN
Learning objectives	• Identify the different steps in the preparation, design, implementation and management of space exploration programs. • Illustrate a particular aspect of the scientific approach which is the development of international space exploration programs involving large budgets and based on the collaboration of many scientists. • Present the objectives and challenges of these major international projects, as well as the results and scientific advances they have achieved.
Contents	- History of the solar system - Structure and dynamics of planets and moons highlighted by space missions - Operating modes of international space science projects This unit provide to the student the most recent news in space exploration programs. The on-site or virtual visit of the ESTEC center offers the student a unique opportunity to discover the many facilities associated to the preparation, design, implementation and management of space exploration programs. Particular emphasis will be placed on the missions or projects that are dedicated to the study of solid planets and satellites and /or to the study of the origins of our solar system.
Teaching and assessment methods	Conferences + on-site or virtual visits of the ESTEC center + project by group around the conception of a space mission related to space actuality.

Planetary analogs

Affiliated TU: M2 EPS-S1	
Duration: 48h	Number of ECTS: 5
Year/semester: M2/S3	Language: English
Main teacher	Antoine BEZOS
Learning objectives	• Apply planetary geology principles and concepts to analyze the evolution of intraoceanic plate volcano, from its construction to its destruction. • Collect field observations at the landscape and outcrop scales, analyze and interpret field data. • Evaluate the relationship between volcanic processes, geodynamic settings, and erosional mechanisms in shaping planetary surfaces. • Analyze viscous flows on the volcanic slopes as analogues of viscous flows on planetary surfaces (silicate melts, ice, etc.). • Evaluate of silicate melt viscosity using petrographic and LA-ICP-MS analyses, as well as morphological measurements of lava flows.
Contents	Field Trip to Tenerife (one week) Practical courses: evaluation of silicate melt viscosity

Teaching and assessment methods	Outdoor observations. Practical courses.

Science and Research Communication

Affiliated TU: M2 EPS-S1			
Duration: 16h		Number of ECTS: 1	
Year/Semester: M2/S3			Language: English
Main teacher	Olivier VERHOEVEN, Bruno JESUS		
Learning objectives	• Analyze any type of scientific publication • Organize a literature review • Summarize any type of scientific publication • Present a research topic in a condensed and clear way • Search for research positions and apply for them • Understand the process of scientific communication and the publish process		
Contents	1 – What are sciences, scientific hypothesis and the scientific method 2 - The world of scientific journals 3 – The peer review system and the scientific impact metrics 4 – Authorship criteria 5 – Writing scientific papers 6 – Oral and poster presentations 7 – Looking for research positions 8 – Managing the research process and coping with the research environmental conditions.		
Teaching and assessment methods	Presential/face to face: Group discussions on the topics presented. Several demonstrations are also offered on how to improve scientific communication and simplify written language. Presentation of the various topics and systematic presentation of positive and negative examples. Collaborative work to find the right solutions. Writing examples of scientific communication to reinforce the concepts taught…		

Earth and Planetary Surface Processes

Affiliated TU: M2 EPS-S1			
Duration: 40h		Number of ECTS: 5	
Year/semester: M1/S1			Teaching language: English
Main teacher	Laetitia LE DEIT		
Learning objectives	• Apply geological concepts, theories and methods to the study of planetary surfaces. • Recognize, analyze and interpret planetary surface land systems and mineral assemblages, with reference to geological models. • Assess the relevance of observational data, experimental data and models for the interpretation of surface processes on the Earth and other bodies of the Solar System. • Determine planetary surface ages. • Produce mineralogical, morphological and geological maps of planetary surfaces. • Review and criticize scientific papers. • Write critical scientific reviews. • Give oral scientific presentations.		

Contents	Main processes that drive the evolution of icy and rocky surfaces on the Earth, Planets and other Bodies of the Solar System: - deformation processes and landforms, - volcanic processes and landforms, - impact cratering processes and landforms, - erosion, transport and sedimentation processes and landforms, - weathering processes and minerals, - dating planetary surfaces, - mineralogical, morphological and geological mapping of planetary surfaces.
Teaching and assessment methods	Lectures, literature reviews, critical reading of scientific papers, written and oral presentations, lab work
Bibliography	H. Jay Melosh (2011) Planetary Surface Processes, Cambridge University Press, doi: 10.1017/CBO9780511977848

Earth and Planetary Interiors

Affiliated TU: M2 EPS-S1		
Duration: 40h	Number of ECTS: 5	
Year / Semester: M2/S3	Language: English	
Main teacher	Christophe SOTIN	
Learning objectives	• Translate geophysical and geochemical observables in terms of thermal structure, composition and mechanical properties, • Integrate the physico-chemical mechanisms governing the dynamics of planetary interiors and their thermal evolution, • Understand the physico-chemical couplings between the main constituent domains of planetary interiors, • Relate the diversity of planetary evolutions with their internal structure. • To appropriate the state of the art in studies on the structure and evolution of planetary interiors. • Acquire a critical mind on the subject. • Know how to synthesize one's own knowledge in English, both written and oral.	
Contents	Descriptive parameters of planetary internal structures Knowledge and the interrogations brought by terrestrial observations and space missions (orbital probes and landers) Contributions and feasibility of different geophysical methods in planetology Comparative structures and evolutions of the solid bodies of the solar system Extrapolation to exoplanets The course is organized to provide a state of the art of the research on the structure and physico-chemical evolution of planetary interiors, including the Earth, with particular examples selected according to space missions. The knowledge acquired in previous years is used to characterize the physico-chemical structure of planetary bodies and to quantify the mechanisms that govern their evolution.	
Teaching and assessment methods	Lectures, case studies. Analysis and discussion of recent articles. Classic problem solving in tutorials. Seminars will allow students to present their analyses and discuss those of their peers. Assessment: synthesis work and exam.	

Bibliography	Free access to the main journals of the discipline, e.g., Astronomy and Astrophysics, Icarus, Journal of Geophysical Research (Solid Earth, Planets), Geophysical Research Letters, Earth and Planetary Science Letters, Nature (Geoscience, Astronomy), Science, ...
Prerequisites	Training in geophysics, geochemistry and/or mechanics, mathematical physics.

Earth and Planetary Remote Sensing

Affiliated TU: M2 EPS-S1		
Duration: 32h	Number of ECTS: 3	
Year/semester: M2/S3		Language: English
Main teacher	Laetitia LE DEIT – Pierre GERNEZ	
Learning objectives	At the end of the course, students will be able to • Understand what physico-chemical information can be extracted from imaging spectrometer data acquired over Earth and other planets and moons of the solar system • Correct hyperspectral images from atmospheric effects using empirical and physical approaches • Extract quantitative information from hyperspectral images • Use hyperspectral images to map surface compositions • Understand how light propagates into the ocean • Understand how above-water reflectance can be used to quantitavely retrieve biogeophysical information on the main seawater colored constituent • Download ocean color satellite data from several web portals • Read OC satellite data, and apply several turbidity and chlorophyll inversion algorithms • Draw chlorophyll concentration and turbidity maps • Estimate the influence of turbidity and chlorophyll concentration on oysters using satellite data	
Contents	- Physical principles of hyperspectral remote sensing (imaging spectroscopy) - Image quality - Image calibration - Atmospheric correction methods - Extraction of physico-chemical parameters - Surface composition, grain size, moisture Contents, etc. - Application to Earth and Planetary surfaces - First concepts in marine optics: inherent and apparent optical properties - Main seawater colored constituants - Introduction to ocean color remote sensing: chlorophyll algorithms in case 1 waters - Ocean color remote sensing in coastal waters - Particular case of turbid waters: turbidity and chlorophyll algorithms - Application of Ocean color remote sensing to bivalve aquaculture	
Teaching and assessment methods	Face to face and possibly E- learning Lectures: theory (physics) and examples of applications. Practical work: hyperspectral image processing through various applications, quantitative mapping, classification, spectral indices, etc. Project to be chosen from various topics (environmental geology on Earth, mineral mapping on Earth, Mars, the Moon, ice on Mars, etc.) individually or in small groups. Assessment based on written report and oral presentation of results.	

Bibliography	Textbooks • Mobley, C., 1994. Light and Water. Academic Press. • Kirk, J.T.O., 1994, Light and Photosynthesis in Aquatic Ecosystems, Second Edition. Cambridge University Press. Websites • http://www.oceanopticsbook.info

Geographic Information Systems 2

Affiliated TU: M2 EPS-S1	
Duration: 24h	Number of ECTS: 2
Year/semester: M2/S3	Language: English
Main Teacher	Clémence HERNY – Bruno FREIRE BOA DE JESUS
Learning objectives	• Be aware of the usefulness of Geographic Information Systems (GIS) and the possible applications to earth, planetary and environmental sciences. • Understand and master the concepts of geographic and projected coordinate systems, the different data types and associated databases. • Use basic and advanced functions of a GIS (e.g., perform spatial data analysis, automatic data processing, produce complex maps). • Collect data required to implement a GIS in the domain of earth and environmental sciences.
Contents	This teaching unit builds upon concepts introduced in GIS 1 and provides a thorough overview of GIS functions required to perform combined analyses of spatial datasets in earth and environmental sciences. Fundamental GIS concepts are presented in the form of lectures. Technical skills are developed by hands-on training using concrete examples applied to earth and environmental sciences. - <u>Fundamental GIS concepts</u>: Definition and scope; Geographic and projected coordinate systems; Spatial data types (vector, raster, attributes); Metadata; Databases; Data suppliers; Web services; GIS softwares; GIS infrastructures. - <u>Advanced spatial data analyses</u>: Managing spatial data; Creating and editing vector data; Operations with vector data (field calculations and geometry operations); Operations with raster data (classifications, data extraction); Georeferencing raster data; Joins and relates; Spatial statistics; - <u>Automation of data processing</u> (batch processing, models, Python and SQL scripting). - Produce complex maps using appropriate semiology and mandatory information
Teaching and assessment methods	Face to face: Fundamental GIS concepts are presented in the form of lectures. Technical skills are developed by hands-on training using GIS on concrete examples applied to earth, planetary, and environmental sciences. Assessment: written exam (40 %) and project (60%): problem resolving report demonstrating the student ability to transfer knowledge and technical skills to a new context
Prerequisites	Basic GIS concepts and practical work covered by GIS1

Lab analyses and field geophysics

Affiliated TU: M2 EPS-S1	
Duration: 35h	Number of ECTS: 4
Year/semester: M2/S3	Language: English
Main teacher	Yann MORIZET
Learning objectives	• Synthesize in a report chemical, mineralogical and geophysical data obtained from laboratory analyses and experiments as well as field work, • Qualitatively and quantitatively describe the behavior of natural systems and the principles of geophysical measurement using mathematical models based on physics, • Perform analyses by applying a specific protocol and geophysical processing through numerical software, • Calculate structural chemical formulas of minerals and report them in ternary diagrams in order to identify them. • Perform syntheses of materials under extreme conditions and characterize the recovered samples using state of the art analytical techniques.
Contents	Vibrational spectroscopy, mineralogy, chemistry, high-pressure experiments, and field geophysics (sismic, gravimetry and magneto-telluric)
Teaching and assessment methods	The teaching is divided as follow: a presentation of each project and the scientific bases required and one week of research project conducted by the students under supervision.
Prerequisites	Basic chemistry, basic physics and mathematics

Data Analysis

Affiliated TU: M2 EPS-S1	
Duration: 24h	Number of ECTS: 2
Year/semester: M2/S3	Language: English
Main teacher	Olivier VERHOEVEN, Laurent BARILLE
Learning objectives	• Analyze, interpret and model data associated with different space and time scales • Identify the appropriate analysis technics according to the nature and the type of data. • Learn the limits of the different data processing techniques. • Master the statistical tool in data characterization. • Master Python as programming language and use data processing software.
Contents	This course provides an overview of the numerical tools needed to analyze, model and interpret time series and spatial data for disciplines ranging from ecology and paleoenvironments, to planetary geosciences. The analysis of time series will be based on the application of different methods such as Fourier transforms, time-frequency representations, wavelets, Dynamic Linear Models and correlation detection techniques. Signal processing methods such as the use of filters and outlier detection will also be discussed.
Teaching and assessment methods	Face-to-face. The teaching are based on lectures and practicals, focusing on different methods to characterize time series from different disciplinary fields. Assessment by mini tests

Bibliography	- Méthodes et techniques de traitement du signal - 5ème édition, Jacques Max, Jean Louis Lacoume, Sciences Sup, Dunod, 2004. - Une exploration des signaux en ondelettes, S. Mallat, Les Editions de l'Ecole Polytechnique, 2000. - Analyse continue par ondelettes, B. Torresani, Savoirs actuels -Interéditions/CNRS éditions, 1995. - Application de la théorie des ondelettes, V. Perrier, Enseignement UNESCO Traitement du signal et des images numériques, Tunis, ENIT, 14-18 mars 2005. - Linear algebra, signal processing, and wavelets. A unified approach. Python version , Øyvind Ryan, 2015. - Ondelettes continues en Sciences de la Terre - méthodes et applications, P. Gaillot, Université Paul Sabatier - Toulouse III, 2000.

Teaching Unit (TU): M2 EPS S1 – UEL (Optionnal course)

English for Scientific Communication-Online Course - Optionnal

Affiliated TU: M2 EPS-S1	
Duration: 6h	Nombre d'ECTS:
Year/semester: M2/S1	Language: English
Main teacher	Sylvie KERVISION – Alice TOWNEND
Learning objectives	Upon completion of the "English for Scientific Communication - Online Course" module, students should be able to: • Effectively consult and evaluate scientific publications in their field of specialisation • Design and maintain a lexical database of verbs and expressions useful for writing scientific publications • Become familiar with common linguistic situations in research: translation, writing abstracts and articles, peer reviewing, oral presentations • Communicate effectively in writing and orally in a scientific and institutional context
Contents	Research articles and publications Technical English (research) Translation and editing of articles
Teaching and assessment methods	E-Learning
Bibliography	Glasman-Deal, Hilary. *Science Research Writing for Non-Native Speakers of English*. Imperial College Press, 2009. Goodson, Patricia. *Becoming an Academic Writer. 50 Exercises for Paced, Productive, and Powerful Writing*. Sage Publications, 2012. Wallwork, Adrian. *English for Writing Research Papers*. Springer US, 2011

Internship

Affiliated TU :M2 EPS-S2		
Duration:	Number of ECTS: 30	
Year/semester: M2/S4		
Main teacher	Olivier BOURGEOIS	
Learning objectives	• Acquire, process, analyze and interpret scientific and technical data • Define or insert yourself into a project in a professional environment • Carry out and present a project in a professional environment • Remobilize your theoretical knowledge in a complex professional context • Place your work in a scientific, technical, industrial, economic or societal context • Make effective written and oral presentations in a professional context • Work independently and in a team • Concretely apply job search techniques • Insert yourself into professional networks	
Contents	The aim of the internship is to introduce the student to professional life by producing an original research work under the supervision of a tutor. The internship must last at least 5 months and at most 6 months. The organisation and its localisation as well as the subject of the internship and research project must be approved by the by the Joint Management Program Committee (JPMC) of the EMJM Program. The dissertation will be submitted to a jury appointed by the JPMC. All internships will be supervised locally at the internship institution by a local supervisor and tutored by a faculty/researcher from NU. The internship is subject to an agreement signed between Nantes University, the intern and the host organisation, in which are indicated the subject of the internship, the name of the professional supervisor and of the university referent teacher. The professional supervisor manages the work of the intern. The referent teacher ensures the smooth running of the internship by guiding the student from the drafting of the internship agreement to the defence.	
Teaching and assessment methods	Professional immersion in academic research, industry or administration. The professional supervisor manages the work of the intern. The referent teacher ensures the smooth running of the internship by guiding the student from the drafting of the internship agreement to the defence. Finding the internship is the responsibility of the student, and his internship project must be validated by the head of the Master program before signing the agreement. At the end of the research project, the student will have to submit a report and defend it during an oral presentation	

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