EARTH AND ENVIRONMENTAL SCIENCES

Departmental Offices:
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Directors of Undergraduate Studies:

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The undergraduate major in Earth and environmental sciences provides an understanding of the natural functioning of our planet and considers the consequences of human interactions with it. Our program for majors aims to convey an understanding of how the complex Earth system works at a level that encourages students to think creatively about the Earth system processes and how to address multidisciplinary environmental problems. The breadth of material covered provides an excellent background for those planning to enter the professions of law, business, diplomacy, public policy, teaching, journalism, etc. At the same time, the program provides sufficient depth so that our graduates are prepared for graduate school in one of the Earth sciences. The program can be adjusted to accommodate students with particular career goals in mind.

The department's close affiliations with the Lamont-Doherty Earth Observatory, the American Museum of Natural History (AMNH), NASA's Goddard Institute for Space Studies (GISS), the Earth Institute at Columbia (EI), and several departments within the Fu Foundation School of Engineering and Applied Sciences afford opportunities for student participation in a wide variety of current research programs. Summer employment, research, and additional educational opportunities are available at Lamont and GISS. The department encourages majors to become involved in a research project by their junior year.

All majors and concentrators, when planning their programs of study, should regularly consult the directors of undergraduate studies and make themselves aware of the requirements for their particular program.

Programs of Study

Environmental Science Major

The environmental science major curriculum provides an introduction to a variety of fields of study relevant to the environment. Environmental science majors are required to take three semesters of introductory courses and to develop a grounding in basic physics, chemistry, biology, and mathematics. Here, students may select courses depending on their interest. With this introduction to the Earth's environment and equipped with a knowledge of the basic sciences, students are prepared to choose a set of upper-level courses in consultation with an undergraduate adviser. All environmental science majors are required to complete a research project, providing a practical application of mastered course work. This research culminates in a senior thesis. The research and the thesis are usually done at Lamont-Doherty Earth Observatory with guidance from a faculty member or a research scientist. However, other options are also possible.

Environmental science majors have an option to complete the special concentration in environmental biology for environmental science majors.

Earth Science Major

The major in Earth science follows a similar rationale but is designed to allow students to pursue particular fields of the Earth sciences in greater depth. Compared with the environmental science major, one fewer introductory course is required, while one additional advanced course should be part of the plan of study. The Earth science major also offers the possibility of in-depth field experience through a six- to eight-week geology summer field course, arrangements for which are made through another university. The research and senior thesis capstone requirements are the same as for the environmental science major. The geology summer field course may be used as an alternative means of fulfilling the capstone requirement in the Earth science major.

Concentrations

The program for concentrators serves students who want more exposure to Earth and environmental science than is provided by introductory-level courses. The program aims to provide concentrators with experience in data analysis and a thorough introduction to the Earth's systems.

The concentrations in environmental science and in Earth science are designed to give students an understanding of how the Earth works and an introduction to the methods used to investigate Earth processes, including their capabilities and limitations. Concentrators often join the social professions (e.g., business, law, medicine, etc.) and take with them a strong scientific background. They take the same introductory courses as the majors, but fewer basic science and upper-level courses are required.

In addition to the environmental science and Earth science concentrations, the department sponsors a special concentration which must be done in conjunction with the environmental biology major. Students should be aware that they must complete the environmental biology major in order to receive credit for the special concentration. There is also a special concentration in environmental biology for environmental science majors sponsored by the Department of Ecology, Evolution, and Environmental Biology.

Departmental Honors

The Department of Earth and Environmental Science awards departmental honors to the major or majors in Earth science or environmental science judged to have the best overall academic record. The award is accorded to no more than 10% of the graduating class, or one student in the case of a class smaller than 10. A grade point average of at least 3.6 in the major and a senior thesis or equivalent research of high quality are required. Students who wish to be considered should contact the director of undergraduate studies early in their senior year.

Professors

Nicholas Christie-Blick
Joel E. Cohen
Peter B. de Menocal
Hugh Ducklow
Sonya Dyhrman
Peter Eisenberger
Göran Ekström
Arlene M. Fiore
Steven L. Goldstein
Arnold L. Gordon
Kevin L. Griffin
Alex Halliday
Sidney R. Hemming (Chair)
Bärbel Hönisch
Peter B. Kelemen
Galen McKinley
Jerry F. McManus (Associate Chair)
William H. Menke
John C. Mutter
Meredith Nettles
Paul E. Olsen
Terry A. Plank
Lorenzo M. Polvani
G. Michael Purdy
Peter Schlosser
Christopher H. Scholz
Adam H. Sobel
Sean C. Solomon
Marc Spiegelman
Martin Stute (Barnard)
Maria Tolstoy
Renata Wentzcovich

Associate Professors

Ryan Abernathey
Kerry Key
Heather Savage

Assistant Professors

Jacqueline Austermann
Roisin Commane
Jonathan Kingslake
Yves Moussallam

Adjunct Professors

Robert F. Anderson
W. Roger Buck IV
Denton Ebel
John J. Flynn
James Gaherty
Lisa M. Goddard
Arthur Lerner-Lam
Alberto Malinverno
Douglas G. Martinson
Ronald L. Miller
Mark A. Norell
Dorothy M. Peteet
Maureen Raymo
Andrew Robertson
Joerg M. Schaefer
Christopher Small
Minfang Ting
Felix Waldhauser
Spahr C. Webb
Gisela Winckler

Adjunct Associate Professors

Alessandra Giannini
Andrew Juhl

Lecturers

Pietro Ceccato
Cornelia Class
Andreas Turnherr
Kevin Uno
Christopher Zappa

Associates

Erin Coughlin
Brian Kahn
Andrew Kruczkiewicz
Catherine Vaughan

Emeritus

Mark Cane
James Hays
Paul Richards
Lynn Sykes
David Walker

Guidelines for all Earth and Environmental Sciences Majors, Concentrators, and Special Concentrators

Advising

All majors and concentrators, when planning their programs of study, should regularly consult the directors of undergraduate studies, who can be contacted through the department office on the fifth floor of Schermerhorn. The requirements are different for each major and concentration and must be met in conjunction with the general requirements for the bachelor's degree. Declaration of the major must be approved by the department and filed in the departmental office.

Substitutions and Exceptions

1. Higher-level courses may be used to satisfy supporting mathematics and science requirements for students with Advanced Placement preparation with the permission of the major adviser.
2. In addition to the courses listed for the depth, and breadth and related courses requirements, several graduate-level courses offered in the department as well as several advanced courses offered at Barnard may be substituted with the permission of the major adviser.
3. *1000*-level courses in the Earth and Environmental Sciences Department can not be used toward meeting the requirements of any of the majors, concentrations, or special concentrations.
4. The following course is not suitable for undergraduates and can not be used toward meeting any of the requirements for the majors,

concentrations, or special concentrations: EESC GU4930 Earth's Oceans and Atmosphere.

Grading

A grade of C- or better must be obtained for a course to count toward the majors, concentrations, or special concentrations. The grade of P is not acceptable, but a course taken Pass/D/Fail may be counted if and only if the P is uncovered by the Registrar's deadline.

Major in Earth Science

Please read *Guidelines for all Earth and Environmental Sciences Majors, Concentrators, and Special Concentrators* above.

The major in Earth science requires a minimum of 45.5 points, distributed as follows:

Foundation Courses

EESC UN2100	Earth's Environmental Systems: The Climate System
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH

Students who wish to take both EESC UN2100 Earth's Environmental Systems: The Climate System and EESC UN2300 Earth's Environmental Systems: The Life System can include one of these under breadth and related fields below.

Supporting Mathematics and Science Courses

One semester of Calculus at the level of Calculus I or higher (3 credits)	
MATH UN1101	CALCULUS I
Select one of the following three-course sequences:	
CHEM UN1403 - CHEM UN1404 - PHYS UN1201	GENERAL CHEMISTRY I-LECTURES and General Chemistry II (Lecture) and General Physics I
CHEM UN1403 - PHYS UN1201 - PHYS UN1202	GENERAL CHEMISTRY I-LECTURES and General Physics I and General Physics II

Capstone Experience

Select one of the following:	
EESC BC3800 - EESC UN3901	Senior Research Seminar and Environmental Science Senior Seminar
EESC BC3801 - EESC UN3901	Senior Research Seminar and Environmental Science Senior Seminar
A six to eight week summer geology field course	

Breadth and Related Fields Requirement

A minimum of 6 points (two courses) chosen with the major adviser are required.

Breadth and related field courses are science courses relevant for an Earth science major that do not require an Earth science background. Several such courses are offered at the *2000-*, *3000-* and *4000*-level in the department and at Barnard. Examples include:

EESC UN2100	Earth's Environmental Systems: The Climate System
EESC UN2300	Earth's Environmental Systems: The Life System
EESC UN3010	Field Geology
EESC BC3017	Environmental Data Analysis
EESC GU4050	Global Assessment and Monitoring Using Remote Sensing
EESC GU4600	Earth Resources and Sustainable Development
EESC GU4917	Earth/Human Interactions
EAEE E2002	ALTERNATIVE ENERGY RESOURCES

Also included among breadth and related fields courses are science, mathematics, statistics, and engineering courses offered by other departments that count toward fulfilling degree requirements in those departments.

Depth Requirement

A minimum of 12 points (four courses) chosen with the major adviser to provide depth in the field of Earth science.

These courses build on the foundation and supporting courses listed above and provide a coherent focus in some area of Earth science. Students should include at least one of the following in their course of study:

EESC UN3101	Geochemistry for a Habitable Planet
or EESC UN3201	Solid Earth Dynamics

Areas of focus include one of the courses listed above and three or more additional courses. Students are not required to specialize in a focus area, but examples are given below for those who choose to do so.

Geological Science	
EESC GU4090	Introduction to Geochronology and Thermochronology
EESC GU4113	INTRODUCTION TO MINERALOGY I
EESC GU4223	SEDIMENTARY GEOLOGY
EESC GU4230	Crustal Deformation
EESC GU4701	Introduction to Igneous Petrology
EESC GU4887	Isotope Geology I
EESC GU4947	Plate Tectonics
It is strongly recommended that students focusing in geological science take the summer geology field course as their capstone experience.	
Geochemistry	
EESC UN3015	The Earth's Carbon Cycle
EESC BC3016	Environmental Measurements
EESC BC3200	Ecotoxicology
EESC GU4090	Introduction to Geochronology and Thermochronology
EESC GU4113	INTRODUCTION TO MINERALOGY I
EESC GU4701	Introduction to Igneous Petrology
EESC GU4885	The Chemistry of Continental Waters
EESC GU4887	Isotope Geology I
EESC GU4926	Principles of Chemical Oceanography
It is recommended that students focusing in geochemistry take CHEM UN1403-CHEM UN1404 General Chemistry I and II, and PHYS UN1201 General Physics I as their supporting science sequence.	
Atmosphere and Ocean Science	
EESC GU4008	Introduction to Atmospheric Science
EESC GU4920	Paleoceanography
EESC GU4924	Introduction to Atmospheric Chemistry
EESC GU4925	Principles of Physical Oceanography
EESC GU4926	Principles of Chemical Oceanography

It is recommended that students focusing on atmosphere and ocean science also take a course in fluid dynamics and a course in differential equations.

Solid Earth Geophysics	
EESC GU4230	Crustal Deformation
EESC GU4300	The Earth's Deep Interior
EESC GU4937	Cenozoic Paleoceanography
EESC GU4947	Plate Tectonics
EESC GU4949	Introduction to Seismology
It is recommended that students focusing in solid Earth geophysics take PHYS UN1201-PHYS UN1202 General Physics I and II, and CHEM UN1403 General Chemistry I as their supporting science sequence and also take MATH UN1201 Calculus II.	
Climate	
EESC UN3015	The Earth's Carbon Cycle
EESC BC3025	Hydrology
EESC GU4008	Introduction to Atmospheric Science
EESC GU4330	Introduction to Terrestrial Paleoclimate
EESC GU4835	Wetlands and Climate Change
EESC GU4920	Paleoceanography
EESC GU4924	Introduction to Atmospheric Chemistry
EESC GU4925	Principles of Physical Oceanography
EESC GU4937	Cenozoic Paleoceanography
Paleontology	
EESC GU4223	SEDIMENTARY GEOLOGY
EESC GU4550	Plant Ecophysiology
EESC GU4920	Paleoceanography
EESC GU4924	Introduction to Atmospheric Chemistry
EESC GU4937	Cenozoic Paleoceanography
It is recommended that students focusing in paleontology take EESC UN2300 Earth's Environmental Systems: The Life System, as one of their foundation courses.	

Major in Environmental Science

Please read *Guidelines for all Earth and Environmental Sciences Majors, Concentrators, and Special Concentrators* above.

The major in environmental science requires a minimum of 47 points, distributed as follows:

Foundation Courses

EESC UN2100	Earth's Environmental Systems: The Climate System
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300	Earth's Environmental Systems: The Life System

Supporting Mathematics and Science Courses

One semester of Calculus at the level of Calculus I or higher (3 credits)	
MATH UN1101	CALCULUS I
Select one of the following three-course sequences:	
CHEM UN1403 - CHEM UN1404 - PHYS UN1201	GENERAL CHEMISTRY I-LECTURES and General Chemistry II (Lecture) and General Physics I
CHEM UN1403 - PHYS UN1201 - PHYS UN1202	GENERAL CHEMISTRY I-LECTURES and General Physics I and General Physics II
CHEM UN1403 - EEEB UN2001 - PHYS UN1201	GENERAL CHEMISTRY I-LECTURES and Environmental Biology I: Elements to Organisms and General Physics I

Capstone Experience

EESC BC3800	Senior Research Seminar
or EESC BC3801	Senior Research Seminar
EESC UN3901	Environmental Science Senior Seminar

Breadth and Related Fields Requirement

A minimum of 6 points (two courses) chosen with the major adviser are required.

Breadth and related field courses are science courses relevant for an environmental science major that do not require an environmental science background. Several such courses are offered at the *2000-*, *3000-* and *4000*-level in the department and at Barnard. Examples include:

EESC BC3017	Environmental Data Analysis
EESC GU4050	Global Assessment and Monitoring Using Remote Sensing
EESC GU4600	Earth Resources and Sustainable Development
EESC GU4917	Earth/Human Interactions
EESC UN3010	Field Geology

Also included among breadth and related fields courses are science, mathematics, statistics, and engineering courses offered by other departments that count toward fulfilling degree requirements in those departments.

Depth Requirement

A minimum of 9 points (three courses) chosen with the major adviser to provide depth in the field of environmental science.

These courses build on the foundation and supporting courses listed above and provide a coherent focus in some area of environmental science. Students should include at least one of the following in their course of study:

EESC UN3101	Geochemistry for a Habitable Planet
or EESC UN3201	Solid Earth Dynamics

Areas of focus include one of the courses listed above and two or more additional courses. Students are not required to specialize in a focus area, but examples are given below for those who choose to do so.

Environmental Geology	
EESC GU4076	Geologic Mapping
EESC GU4480	Paleobiology and Earth System History
EAEE E3221	Environmental geophysics
It is recommended that students focusing in environmental geology also take EESC W4050 Remote Sensing.	
Environmental Geochemistry	
EESC UN3015	The Earth's Carbon Cycle
EESC GU4885	The Chemistry of Continental Waters
EESC GU4887	Isotope Geology I
EESC GU4924	Introduction to Atmospheric Chemistry
EESC GU4888	Stable Isotope Geochemistry
EESC GU4926	Principles of Chemical Oceanography
Hydrology	

EESC GU4076	Geologic Mapping
EESC GU4835	Wetlands and Climate Change
EESC GU4885	The Chemistry of Continental Waters
EESC BC3025	Hydrology
EAEE E3221	Environmental geophysics
Climate Change	
EESC UN3015	The Earth's Carbon Cycle
EESC GU4008	Introduction to Atmospheric Science
EESC GU4330	Introduction to Terrestrial Paleoclimate
EESC GU4480	Paleobiology and Earth System History
EESC GU4835	Wetlands and Climate Change
EESC GU4920	Paleoceanography
It is recommended that students focusing in environmental geology also take EESC GU4050 Remote Sensing.	
Energy and Resources	
EESC GU4076	Geologic Mapping
EESC GU4701	Introduction to Igneous Petrology
EAEE E2002	ALTERNATIVE ENERGY RESOURCES

Concentration in Earth Science

Please read *Guidelines for all Earth and Environmental Sciences Majors, Concentrators, and Special Concentrators* above.

The concentration in Earth science requires a minimum of 25 points, distributed as follows:

Foundation Courses

EESC UN2100	Earth's Environmental Systems: The Climate System
or EESC UN2300	Earth's Environmental Systems: The Life System
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH

Supporting Mathematics and Science Courses

Two science or mathematics courses (6-7 points) selected from among those listed for the Earth science major above.

Depth and Breadth and Related Fields Requirements

A minimum of 10 points (typically three courses) is required as follows:

EESC UN3101	Geochemistry for a Habitable Planet
or EESC UN3201	Solid Earth Dynamics
One additional course chosen from those listed under Depth Requirement for the earth science major above.	
The third course selected from those listed under either Depth Requirement or Breadth and Related Fields Requirement for the earth science major above.	

Concentration in Environmental Science

Please read *Guidelines for all Earth and Environmental Sciences Majors, Concentrators, and Special Concentrators* above.

The concentration in environmental science requires a minimum of 25.5 points, distributed as follows:

Foundation Courses

EESC UN2100	Earth's Environmental Systems: The Climate System
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300	Earth's Environmental Systems: The Life System

Supporting Mathematics and Science Courses

Two science or mathematics courses (6-7 points) selected from among those listed for the environmental science major above.

Depth and Breadth and Related Fields Requirements

A minimum of 6 points (two courses) is required as follows:

EESC UN3101	Geochemistry for a Habitable Planet
or EESC UN3201	Solid Earth Dynamics
One additional course selected from those listed under either Depth Requirement or Breadth and Related Fields Requirement for the environmental science major above.	

Special Concentration in Environmental Science for Majors in Environmental Biology

Please read *Guidelines for all Earth and Environmental Sciences Majors, Concentrators, and Special Concentrators* above.

The Department of Earth and Environmental Sciences sponsors a special concentration which must be done in conjunction with the environmental biology major. Students should be aware that they must complete the environmental biology major in order to receive credit for the special concentration.

The special concentration in environmental science requires a minimum of 31.5 points, distributed as follows:

Introductory Environmental Science (13.5 points)

EESC UN2100	Earth's Environmental Systems: The Climate System
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300	Earth's Environmental Systems: The Life System

Introductory Science (6 points)

Two courses in chemistry, physics, mathematics, or environmental biology from the supporting mathematics and science list for the environmental science major above.

Advanced Environmental Science (12 points)

Four courses at the 3000-level or above chosen from those recommended for the environmental science major above.

Advanced courses used to fulfill requirements in the environmental biology major cannot count toward requirements for the special concentration.

Special Concentration in Environmental Biology for Majors in Environmental Science

Please read *Guidelines for all Earth and Environmental Sciences Majors, Concentrators, and Special Concentrators* above.

The Department of Ecology, Evolution, and Environmental Biology sponsors a special concentration which must be done in conjunction with the environmental science major. Students should be aware that they must complete the environmental science major in order to receive credit for the special concentration.

The special concentration in environmental biology requires a minimum of 39 points, distributed as follows:

Introductory Environmental Biology and Environmental Science (17 points)

EEEB UN2001	Environmental Biology I: Elements to Organisms
EESC UN2100	Earth's Environmental Systems: The Climate System
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EEEB UN2002	Environmental Biology II: Organisms to the Biosphere

Introductory Science (13 points)

Select one of the following chemistry sequences:	
CHEM UN1403 - CHEM UN1404	GENERAL CHEMISTRY I-LECTURES and General Chemistry II (Lecture)
CHEM UN1604 - CHEM UN2507	2ND TERM GEN CHEM (INTENSIVE) and Intensive General Chemistry Laboratory
One term of statistics such as the following:	
STAT UN1101	Introduction to Statistics
STAT UN1201	Calculus-Based Introduction to Statistics
BIOL BC2286	Statistics and Research Design
EEEB UN3005	Introduction to Statistics for Ecology and Evolutionary Biology
EEEB UN3087	Conservation Biology

Advanced Environmental Biology (9 points)

Three additional advanced EEEB courses (3000-level and above), each chosen from a different curricular area (evolution/genetics, ecology/behavior/conservation, anatomy/physiology/diversity, biology laboratory courses).

Advanced courses used to fulfill requirements in the environmental science major cannot count toward requirements for the special concentration.

Sustainable Development

Students interested in sustainable development should refer to the *Sustainable Development* section in this Bulletin.

Fall 2021

EESC UN1001 Dinosaurs and the History of Life: Lectures and Lab. *4 points*.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: Recommended preparation: basic high school science and math.
Lab is a hands-on introduction to geochronology, paleontology, and historical geology with field trips. (See W1401 for lectures only.) Dinosaurs: a spectacular example of a common, highly successful form of life, dominant for 135 million years. Where did they come from? Why were they so successful? Why did they die out? A basic introduction to interface between geology and biology.

Fall 2021: EESC UN1001

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1001	001/14067	M W 1:10pm - 2:25pm Room TBA	Paul Olsen	4	0/40
EESC 1001	001/14067	M 4:10pm - 7:00pm 603 Schermerhorn Hall	Paul Olsen	4	0/40

EESC UN1201 Environmental Risks and Disasters. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement
Priority given to first-years and sophomores.

Prerequisites: high school science and math.
An introduction to risks and hazards in the environment. Different types of hazards are analyzed and compared: natural disasters, such as tornados, earthquakes, and meteorite impacts; acute and chronic health effects caused by exposure to radiation and toxic substances such as radon, asbestos, and arsenic; long-term societal effects due to environmental change, such as sea level rise and global warming. Emphasizes the basic physical principles controlling the hazardous phenomena and develops simple quantitative methods for making scientifically reasoned assessments of the threats (to health and wealth) posed by various events, processes, and exposures. Discusses methods of risk mitigation and sociological, psychological, and economic aspects of risk control and management.

Fall 2021: EESC UN1201

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1201	001/12770	M W 10:10am - 11:25am Room TBA	Goran Ekstrom	3	48/75

EESC UN1401 Dinosaurs and the History of Life: Lectures. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: Recommended preparation: basic high school science and math.
Dinosaurs: a spectacular example of a common, highly successful form of life, dominant for 135 million years. Where did they come from? Why were they so successful? Why did they die out? A basic introduction to the interface between geology and biology.

Fall 2021: EESC UN1401

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1401	001/14068	M W 1:10pm - 2:25pm Room TBA	Paul Olsen	3	0/100

EESC UN1600 Earth Resources and Sustainable Development. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: none; high school chemistry recommended.
Survey of the origin and extent of mineral resources, fossil fuels, and industrial materials, that are non renewable, finite resources, and the environmental consequences of their extraction and use, using the textbook Earth Resources and the Environment, by James Craig, David Vaughan and Brian Skinner. This course will provide an overview, but will include focus on topics of current societal relevance, including estimated reserves and extraction costs for fossil fuels, geological storage of CO2, sources and disposal methods for nuclear energy fuels, sources and future for luxury goods such as gold and diamonds, and special, rare materials used in consumer electronics (e.g., "Coltan", mostly from Congo) and in newly emerging technologies such as superconducting magnets and rechargeable batteries (e.g., heavy rare earth elements, mostly from China). Guest lectures from economists, commodity traders and resource geologists will provide "real world" input. Discussion Session Required.

Fall 2021: EESC UN1600

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1600	001/12771	T Th 1:10pm - 2:25pm Room TBA	Peter Kelemen	3	93/150

EESC UN2100 Earth's Environmental Systems: The Climate System. *4.5 points*.
CC/GS: Partial Fulfillment of Science Requirement, BC: Partial Fulfillment of General Education Requirement: Laboratory Science (SCI)., BC: Fulfillment of General Education Requirement: Quantitative and Deductive Reasoning (QUA)., Lab Required
Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be reinstated.

Prerequisites: high school algebra. Recommended preparation: high school chemistry and physics; and one semester of college science.
Origin and development of the atmosphere and oceans, formation of winds, storms and ocean currents, reasons for changes through geologic time. Recent influence of human activity: the ozone hole, global warming, water pollution. Laboratory exploration of topics through demonstrations, experimentation, computer data analysis, and modeling. Students majoring in Earth and Environmental Sciences should plan to take EESC W2100 before their senior year to avoid conflicts with Senior Seminar.

Spring 2021: EESC UN2100

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2100	001/10398	T Th 10:10am - 11:25am 963 Ext Schermerhorn Hall	Mingfang Ting, Gisela Winckler	4.5	47/60
EESC 2100	001/10398	T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall	Mingfang Ting, Gisela Winckler	4.5	47/60

Fall 2021: EESC UN2100

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2100	001/12773	T Th 10:10am - 11:25am 603 Schermerhorn Hall	Jerry McManus, Arlene Fiore	4.5	50/50
EESC 2100	001/12773	T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall	Jerry McManus, Arlene Fiore	4.5	50/50

EESC UN2200 EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH. *4.50 points*.
CC/GS: Partial Fulfillment of Science Requirement
Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be necessary.

Prerequisites: high school algebra and chemistry. Recommended preparation: high school physics.
Prerequisites: high school algebra, chemistry, and physics. Exploration of how the solid Earth works, today and in the past, focusing on Earth in the Solar system, continents and oceans, the Earth's history, mountain systems on land and sea, minerals and rocks, weathering and erosion, glaciers and ice sheets, the hydrological cycle and rivers, geochronology, plate tectonics, earthquakes, volcanoes, energy resources. Laboratory exploration of topics through examination of rock samples, experimentation, computer data analysis, field exercises, and modeling. Columbia and Barnard majors should plan to take W2200 before their senior year to avoid conflicts with the Senior Seminar

Spring 2021: EESC UN2200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2200	001/10400	T Th 2:40pm - 3:55pm 603 Schermerhorn Hall	William Menke, Sidney Hemming	4.50	50/50
EESC 2200	001/10400	T 4:10pm - 7:00pm 603 Schermerhorn Hall	William Menke, Sidney Hemming	4.50	50/50

Fall 2021: EESC UN2200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2200	001/12993	T Th 1:10pm - 2:25pm 603 Schermerhorn Hall	Yves Moussallam, Jonathan Kingslake	4.50	32/50
EESC 2200	001/12993	T 4:10pm - 7:00pm 603 Schermerhorn Hall	Yves Moussallam, Jonathan Kingslake	4.50	32/50

EESC UN2330 SCIENCE FOR SUSTAINABLE DEVPT. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

The course provides students with the natural science basis to appreciate co-dependencies of natural and human systems, which are central to understanding sustainable development. After completing the course, students should be able to incorporate scientific approaches into their research or policy decisions and be able to use scientific methods of data analysis. The semester will highlight the climate system and solutions from both physical and ecological perspectives; water resources; food production and the cycling of nutrients; and the role of biodiversity in sustainable development. The course emphasizes key scientific concepts such as uncertainty, experimental versus observational approaches, prediction and predictability, the use of models and other essential methodological aspects.

Fall 2021: EESC UN2330

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2330	001/12772	T Th 2:40pm - 3:55pm Room TBA	John Mutter, Jenna Lawrence	3	120/120

EESC UN3101 Geochemistry for a Habitable Planet. *3 points*.
Prerequisites: Any 1000-level or 2000-level EESC course; MATH UN1101 Calculus I and CHEM UN1403 General Chemistry I or their equivalents.
The origin, evolution, and future of our planet, based on the book *How to Build a Habitable Planet* by Wallace S. Broecker. This course will focus on the geochemical processes that built Earth from solar material, led to its differentiation into continents and ocean, and have maintained its surface at a comfortable temperature. Students will participate in a hands-on geochemistry project at Lamont-Doherty Earth Observatory.

Fall 2021: EESC UN3101

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3101	001/12774	T Th 11:40am - 12:55pm 417 Schermerhorn Hall	Terry Plank	3	29/35

EESC UN3400 COMPUTATIONAL EARTH SCIENCE. *3.00 points*.
Prerequisites: Required: at least a semester of calculus and physics; any 1000-level or 2000-level EESC,course. Recommended: EESC3201 (Solid Earth Dynamics).
Prerequisites: Required: at least a semester of calculus and physics; any 1000-level or 2000-level EESC course. Recommended: EESC3201 (Solid Earth Dynamics). Computer models are essential for understanding the behavior of complex natural systems in geosciences. This course is an introduction to writing computer models to simulate Earth processes. Students will learn methods for numerical modeling of a variety of geoscience topics, such as geochemical diffusion, groundwater flow, glacier growth, ocean currents and more. Simulations will be created by learning to program using a modern user-friendly programming language. Student learning will be facilitated through a combination of lectures, in-class exercises, homework assignments and a final project on a student-selected topic

Fall 2021: EESC UN3400

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3400	001/12776	T Th 2:40pm - 3:55pm Room TBA	Kerry Key	3.00	11/30

EESC UN3901 Environmental Science Senior Seminar. *3 points*.
Prerequisites: *EESC BC3800* or *EESC BC3801* and a good grounding in basic sciences.
Guided, independent, in-depth research culminating in the senior thesis in the spring. Includes discussion about scientific presentations and posters, data analysis, library research methods and scientific writing. Students review work in progress and share results through oral reports. Weekly seminar to review work in progress and share results through oral and written reports.

Spring 2021: EESC UN3901

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3901	001/11270	Th 4:10pm - 6:00pm Online Only	Jacqueline Austermann, Hugh Ducklow	3	21/40

Fall 2021: EESC UN3901

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3901	001/12777	Th 4:10pm - 6:00pm Room TBA	Spahr Webb, Roisin Commane	3	6/50

EESC GU4008 Introduction to Atmospheric Science. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: advanced calculus and general physics, or the instructor's permission.
Basic physical processes controlling atmospheric structure: thermodynamics; radiation physics and radiative transfer; principles of atmospheric dynamics; cloud processes; applications to Earth's atmospheric general circulation, climatic variations, and the atmospheres of the other planets.

Fall 2021: EESC GU4008

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4008	001/12778	Th 4:10pm - 6:40pm Room TBA	Lorenzo Polvani	3	13/30

EESC GU4020 HUMANS # THE CARBON CYCLE. *3.00 points*.
Prerequisites: One semester of college-level calculus and chemistry; Plus one semester of college-level physics or geoscience. Or instructor's permission. The accelerating climate change of the current day is driven by humanity's modifications to the global carbon cycle. This course offers an introduction basic science of the carbon cycle, with a focus on large-scale processes occurring on annual to centennial timescales. Students will leave this course with an understanding of the degree to which the global carbon cycle is understood and quantified, as well as the key uncertainties that are the focus of current research. We will build understanding of the potential pathways, and the significant challenges, to limiting global warming to 2o C as intended by the 2015 Paris Climate Agreement. The course will begin with a brief review of climate science basics and the role of CO2 in climate and climate change (weeks 1-2). In weeks 3-4, the natural reservoirs and fluxes that make up the global carbon cycle will be introduced. In week 5-6, anthropogenic emissions and the observed changes in climate associated with increasing atmospheric CO2 will be discussed. In weeks 7-11, we will learn about how the land biosphere and ocean are mitigating the increase in atmospheric CO2 and the feedbacks that may substantially modify these natural sinks. In weeks 12-13, the international policy process and the potential for carbon cycle management will be the focus. In weeks 14, students will present their final projects

Fall 2021: EESC GU4020

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4020	001/12779	T Th 11:40am - 12:55pm 555 Ext Schermerhorn Hall	Galen McKinley	3.00	13/25

EESC GU4480 Paleobiology and Earth System History. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: high-school biology, introductory college-level geology.
Course is a survey of the biological and biogeochemical evolution of the Earth System. Students focus not only on a narrative of the panoply of biodiversity though time, but also on the development and the testing of evolutionary and geochemical hypotheses within a historical science. Case studies of mass extinctions and biological innovation as well as current topics and debates will be examined in detail. There are 4 full-day field trips.

Fall 2021: EESC GU4480

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4480	001/14069	T Th 11:40am - 12:55pm 603 Schermerhorn Hall	Paul Olsen	3	0/50

EESC GU4550 Plant Ecophysiology. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: General biology or the instructor's permission.
Given in alternate years. Plant organismal responses to external environmental conditions and the physiological mechanisms of plants that enable these responses. An evolutionary approach is taken to analyze the potential fitness of plants and plant survival based on adaptation to external environmental factors. One weekend field trip will be required.

Fall 2021: EESC GU4550

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4550	001/12857	T Th 1:10pm - 2:25pm 555 Ext Schermerhorn Hall	Kevin Griffin	3	14/25

EESC GU4600 Earth Resources and Sustainable Development. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: none; high school chemistry recommended.
Survey of the origin and extent of mineral resources, fossil fuels, and industrial materials, that are non renewable, finite resources, and the environmental consequences of their extraction and use, using the textbook Earth Resources and the Environment, by James Craig, David Vaughan and Brian Skinner. This course will provide an overview, but will include focus on topics of current societal relevance, including estimated reserves and extraction costs for fossil fuels, geological storage of CO2, sources and disposal methods for nuclear energy fuels, sources and future for luxury goods such as gold and diamonds, and special, rare materials used in consumer electronics (e.g., "Coltan", mostly from Congo) and in newly emerging technologies such as superconducting magnets and rechargeable batteries (e.g., heavy rare earth elements, mostly from China). Guest lectures from economists, commodity traders and resource geologists will provide "real world" input.

Fall 2021: EESC GU4600

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4600	001/12781	T Th 1:10pm - 2:25pm Room TBA	Peter Kelemen	3	24/30

EESC GU4835 Wetlands and Climate Change. *3 points*.
Given in alternate years. Enrollment limited to 20. Priority given to juniors and seniors.

Prerequisites: introductory biology or chemistry, or the instructor's permission.
Analysis of modern wetland dynamics and the important ecological, biogeochemical, and hydrological functions taking place in marshes, bogs, fens, and swamps, with a field emphasis. Wetlands as fossil repositories, the paleoenvironmental history they provide, and their role in the carbon cycle. Current wetland destruction, remediation attempts, and valuation. Laboratory analysis and field trips.

Fall 2021: EESC GU4835

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4835	001/12994	T Th 10:10am - 11:25am 506 Schermerhorn Hall	Dorothy Peteet	3	14/35

Spring 2021

EESC UN2100 Earth's Environmental Systems: The Climate System. *4.5 points*.
CC/GS: Partial Fulfillment of Science Requirement, BC: Partial Fulfillment of General Education Requirement: Laboratory Science (SCI)., BC: Fulfillment of General Education Requirement: Quantitative and Deductive Reasoning (QUA)., Lab Required
Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be reinstated.

Prerequisites: high school algebra. Recommended preparation: high school chemistry and physics; and one semester of college science.
Origin and development of the atmosphere and oceans, formation of winds, storms and ocean currents, reasons for changes through geologic time. Recent influence of human activity: the ozone hole, global warming, water pollution. Laboratory exploration of topics through demonstrations, experimentation, computer data analysis, and modeling. Students majoring in Earth and Environmental Sciences should plan to take EESC W2100 before their senior year to avoid conflicts with Senior Seminar.

Spring 2021: EESC UN2100

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2100	001/10398	T Th 10:10am - 11:25am 963 Ext Schermerhorn Hall	Mingfang Ting, Gisela Winckler	4.5	47/60
EESC 2100	001/10398	T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall	Mingfang Ting, Gisela Winckler	4.5	47/60

Fall 2021: EESC UN2100

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2100	001/12773	T Th 10:10am - 11:25am 603 Schermerhorn Hall	Jerry McManus, Arlene Fiore	4.5	50/50
EESC 2100	001/12773	T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall	Jerry McManus, Arlene Fiore	4.5	50/50

EESC UN2200 EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH. *4.50 points*.
CC/GS: Partial Fulfillment of Science Requirement
Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be necessary.

Prerequisites: high school algebra and chemistry. Recommended preparation: high school physics.
Prerequisites: high school algebra, chemistry, and physics. Exploration of how the solid Earth works, today and in the past, focusing on Earth in the Solar system, continents and oceans, the Earth's history, mountain systems on land and sea, minerals and rocks, weathering and erosion, glaciers and ice sheets, the hydrological cycle and rivers, geochronology, plate tectonics, earthquakes, volcanoes, energy resources. Laboratory exploration of topics through examination of rock samples, experimentation, computer data analysis, field exercises, and modeling. Columbia and Barnard majors should plan to take W2200 before their senior year to avoid conflicts with the Senior Seminar

Spring 2021: EESC UN2200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2200	001/10400	T Th 2:40pm - 3:55pm 603 Schermerhorn Hall	William Menke, Sidney Hemming	4.50	50/50
EESC 2200	001/10400	T 4:10pm - 7:00pm 603 Schermerhorn Hall	William Menke, Sidney Hemming	4.50	50/50

Fall 2021: EESC UN2200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2200	001/12993	T Th 1:10pm - 2:25pm 603 Schermerhorn Hall	Yves Moussallam, Jonathan Kingslake	4.50	32/50
EESC 2200	001/12993	T 4:10pm - 7:00pm 603 Schermerhorn Hall	Yves Moussallam, Jonathan Kingslake	4.50	32/50

EESC UN2300 Earth's Environmental Systems: The Life System. *4.5 points*.
CC/GS: Partial Fulfillment of Science Requirement
Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be reinstated.

Prerequisites: high school algebra. Recommended preparation: high school chemistry and physics.
Role of life in biogeochemical cycles, relationship of biodiversity and evolution to the physical Earth, vulnerability of ecosystems to environmental change; causes and effects of extinctions through geologic time (dinosaurs and mammoths) and today. Exploration of topics through laboratories, demonstrations, computer data analysis and modeling. REQUIRED LAB: *EESC UN2310*. Students should see the Directory of Classes for lab sessions being offered and select one.

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Co-meets with EEEB 2002

Spring 2021: EESC UN2300

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2300	001/10401	M W 11:40am - 12:55pm Online Only	Paul Olsen, Matthew Palmer, Kevin Griffin	4.5	51/70

EESC UN2310 Earth's Environmental Systems: The Life System Required Lab: Sections 001, 002, 003, 004,005. *0 points*.
This three hour lab is required of all students who enroll in *EESC UN2300*. There are currently five lab sections.

Spring 2021: EESC UN2310

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2310	001/10974	W 4:10pm - 7:00pm Online Only	Paul Olsen, Matthew Palmer, Kevin Griffin	0	19/24
EESC 2310	002/10975	W 4:10pm - 7:00pm Online Only	Paul Olsen, Matthew Palmer, Kevin Griffin	0	6/24
EESC 2310	003/11331	W 4:10pm - 7:00pm Online Only	Paul Olsen, Matthew Palmer, Kevin Griffin	0	5/24
EESC 2310	004/13166	Th 4:10pm - 7:00pm Online Only	Paul Olsen, Matthew Palmer, Kevin Griffin	0	16/24
EESC 2310	005/20112	Th 1:10pm - 4:00pm Online Only	Paul Olsen, Matthew Palmer, Kevin Griffin	0	5/24
EESC 2310	006/20113	F 8:10am - 11:00am Online Only	Paul Olsen, Matthew Palmer, Kevin Griffin	0	8/24

EESC UN3010 Field Geology. *3 points*.
Fee: to be determined.

The centerpiece of this course is a field trip that will take place during Spring Break in Barbados. During the term-time the class will meet before the trip to prepare for it and after the trip to synthesize what was learned and to create a field guide. Subjects to be covered: Plate tectonics / convergent plate margins and accretionary prisms / Barbados geology; ice ages / Milankovitch cycles / sea level; introduction to coral reefs and fossil coral reef geology; Barbados terrestrial ecology; limestone caves / hydrology; dating methods; overview of Barbados history, economy, culture. In order to observe the modern day coral reef (the modern day live analog to the fossil coral reefs) the class will go snorkeling. In order to observe the effects of cave formation and water flow in limestone terrains the class will visit a cave. The class will also participate in an exercise in geological mapping of a series of coral reef terraces.

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Priority is given to junior and senior majors and concentrators in the Department of Earth and Environmental Sciences at Columbia College and the School of General Studies, and Barnard Environmental Science majors and minors. Barnard students must receive permission from the Barnard Environmental Science department chair in order to receive the subsidy. All others require the instructor's permission. Interested sophomores planning to major or concentrate in Earth Sciences or Environmental Sciences are encouraged to contact the instructor.
By necessity (number of van seats) the course is limited to 20 or 21 students.

EESC UN3201 Solid Earth Dynamics. *3 points*.
Prerequisites: any 1000-level or 2000-level EESC course; MATH UN1101 Calculus I and PHYS UN1201 General Physics I or their equivalents. Concurrent enrollment in PHYS UN1201 is acceptable with the instructor's permission.
Properties and processes affecting the evolution and behavior of the solid Earth. This course will focus on the geophysical processes that build mountains and ocean basins, drive plate tectonics, and otherwise lead to a dynamic planet. Topics include heat flow and mantle circulation, earthquakes and seismic waves, gravity, Earth's magnetic field, and flow of glaciers and ice sheets.

Spring 2021: EESC UN3201

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3201	001/10402	M W 10:10am - 11:25am 304 Hamilton Hall	Meredith Nettles	3	15/40

EESC UN3328 Glacial Geomorphology. *3.00 points*.
This course focuses on the impact of glaciers on landscapes. We will learn about the interactions and feedbacks between landscapes and climate. We will cover what is known about glacial geomorphology, as well as the modern research methods and outstanding scientific problems

Spring 2021: EESC UN3328

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3328	001/15092	T Th 2:40pm - 3:55pm Online Only	Carly Peltier	3.00	11/15

EESC UN3901 Environmental Science Senior Seminar. *3 points*.
Prerequisites: *EESC BC3800* or *EESC BC3801* and a good grounding in basic sciences.
Guided, independent, in-depth research culminating in the senior thesis in the spring. Includes discussion about scientific presentations and posters, data analysis, library research methods and scientific writing. Students review work in progress and share results through oral reports. Weekly seminar to review work in progress and share results through oral and written reports.

Spring 2021: EESC UN3901

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3901	001/11270	Th 4:10pm - 6:00pm Online Only	Jacqueline Austermann, Hugh Ducklow	3	21/40

Fall 2021: EESC UN3901

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3901	001/12777	Th 4:10pm - 6:00pm Room TBA	Spahr Webb, Roisin Commane	3	6/50

EESC GU4040 CLIM THERMODYN/ENERGY TRANSFER. *3.00 points*.
Given in alternate years.

Prerequisites: EESC GU4008, advanced calculus, and general physics, or the instructor's permission.
Thermodynamics of atmospheric and oceanic processes fundamental to the climate system. Physical mechanisms of vertical energy transfer: surface fluxes, boundary layers and convection

Spring 2021: EESC GU4040

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4040	001/10403	T Th 10:10am - 11:25am 555 Ext Schermerhorn Hall	Adam Sobel	3.00	4/25

EESC GU4085 GEODYNAMICS. *3.00 points*.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: calculus, differential equations, introductory physics.
An introduction to how the Earth and planets work. The focus is on physical processes that control plate tectonics and the evolution of planetary interiors and surfaces; analytical descriptions of these processes; weekly physical model demonstrations

Spring 2021: EESC GU4085

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4085	001/10404	T Th 11:40am - 12:55pm 555 Ext Schermerhorn Hall	W Buck	3.00	8/20

EESC GU4113 INTRODUCTION TO MINERALOGY I. *4.00 points*.
Prerequisites: introductory geology or the equivalent, elementary college physics and chemistry, or the instructor's permission.
Prerequisites: introductory geology or the equivalent, elementary college physics and chemistry, or the instructors permission. Minerals come in dazzling colors, amazing shapes and with interesting optical effects. But mineralogy is also an essential tool for the understanding of Earth evolution. Minerals represent fundamental building blocks of the Earth system and planetary bodies. Minerals form through geological and biological processes such as igneous, metamorphic and sedimentary from high to low temperatures, from the deep interior to the Earth's surface and related to volcanism, tectonics, weathering, climate and life. Minerals are one of our most important sources of information on such processes through Earth's history. Minerals also represent important natural resources and are fundamental to the global economy and modern technology as we know it. The goal of this class is to (1) understand the physical and chemical properties of minerals, (2) learn techniques of mineral identification with an emphasis on optical mineralogy, (3) understand the relationship between minerals and the broader geological context

EESC GU4210 Geophysical Fluid Dynamics. *3 points*.
Required course for M.A./Ph.D. candidates focusing in physical oceanography and atmospheric sciences. Elective for undergraduate majors in the Department of Earth and Environmental Sciences.

Prerequisites: *APMA E3101*, *APMA E3201* or equivalents and *APPH E4200* or equivalent or the instructor's permission.
Fundamental concepts in the dynamics of rotating stratified flows. Geostrophic and hydrostatic balances, potential vorticity, f and beta plane approximations, gravity and Rossby waves, geostrophic adjustment and quasigeostrophy, baroclinic and barotropic instabilities.

Spring 2021: EESC GU4210

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4210	001/10406	Th 4:10pm - 6:40pm Online Only	Lorenzo Polvani	3	15/35

EESC GU4220 Glaciology. *3 points*.
Prerequisites: At least a year of calculus and physics; any 1000-level or 2000-level EESC course. Recommended: EESC2100 (Climate System), EESC2200 (Solid Earth), EESC3201 (Solid Earth Dynamics). Experience using MATLAB.
This course examines processes controlling how glaciers and ice sheets grow, retreat, modify their landscape and interact with the rest of the Earth system. We focus on what controls surface mass balance, the transformation from snow to ice, ice deformation, basal sliding, the temperature and age of ice, the flow of water through ice sheets and glaciers, and the two-way interactions between ice and the oceans, atmosphere and solid earth. Weekly lectures are accompanied by practical computer sessions that equip students with key numerical and data analysis skills used in research of glacial processes.

Spring 2021: EESC GU4220

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4220	001/10407	T Th 1:10pm - 2:25pm Online Only	Jonathan Kingslake	3	6/30

EESC GU4223 SEDIMENTARY GEOLOGY. *4.00 points*.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: EESC UN2200 or equivalent introductory geology course approved by the instructor.
Two required weekend field trips: February 27 to Fire Island, and March 12-14 to the Hudson Valley. An overview of sedimentology and stratigraphy for majors and concentrators in Earth and environmental sciences, and for graduate students from other disciplines. Lectures/class discussions, labs, and field exercises are integrated, with emphasis on processes, the characteristics of sediments and sedimentary rocks, interpretation of the geological record, and practical applications. Lab required

Spring 2021: EESC GU4223

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4223	001/10408	T Th 2:40pm - 3:55pm 506 Schermerhorn Hall	Nicholas Christie-Blick	4.00	6/50
EESC 4223	001/10408	T 4:10pm - 6:30pm 506 Schermerhorn Hall	Nicholas Christie-Blick	4.00	6/50

EESC GU4235 Sea level change. *3 points*.
Prerequisites: At least a year of calculus and physics; any 1000-level or 2000-level EESC course; basic,programming experience (e.g. EESC3400 - Introduction to Computational Earth Science).,Recommended: EESC2100 (Climate System), EESC2200 (Solid Earth), EESC3201 (Solid Earth,Dynamics).
The course aims to explore sea level changes that take place over a wide variety of timescales and are the result of multiple solid Earth and climatic processes. The course will link a series of solid Earth processes such as mantle convection, viscoelastic deformation, and plate tectonics to the paleoclimate record and investigate how these processes contribute to our understanding of past and present changes in sea level and climate. The course will step chronologically through time starting with long term sea level changes over the Phanerozoic, followed by Plio-Pleistocene ice age sea level variations and lastly modern and future sea level change. This is a cross-disciplinary course, which is aimed at students with interests in geophysics, cryosphere evolution, ocean dynamics, sedimentology, paleogeography, and past and present climate

Spring 2021: EESC GU4235

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4235	001/10409	T Th 11:40am - 12:55pm Online Only	Jacqueline Austermann	3	13/20

EESC GU4524 Biogeochemistry. *3.00 points*.
Biogeochemistry considers how the basic chemical conditions of the Earth, from atmosphere to soil to seawater, have been and are being affected by the existence of life. Human activities in particular, from the rapid consumption of resources to the destruction of the rainforests and the expansion of smog-covered cities, are leading to rapid changes in the basic chemistry of the Earth. This course will examine biogeochemical processes in both terrestrial and aquatic ecosystems in Earth's Biosphere. We will cover the historical development and evolution of biogeochemical cycles and compare past biogeochemical systems on the planet to contemporary and future eco-biogeochemical systems that are increasingly perturbed and dominated by human activity

Spring 2021: EESC GU4524

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4524	001/10410	T Th 2:40pm - 3:55pm Online Only	Hugh Ducklow	3.00	8/10

EESC GU4923 Biological Oceanography. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years. Enrollment limited to 24. Priority given to graduate students and then graduating seniors.

Prerequisites: introductory college-level biology and chemistry.
An overview of the biology and ecology of the oceans with a focus on the interaction between marine organisms and the physics and chemistry of the oceans.

EESC GU4924 Introduction to Atmospheric Chemistry. *3 points*.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: Physics UN1201, Chem UN1403, & Math UN1201 (Calc III), or their equivalents. Recommended: EESC UN2100 or EESC GU4008.
Physical and chemical processes determining atmospheric composition and the implications for climate and regional air pollution. Atmospheric evolution and human influence; basics of greenhouse effect, photolysis, reaction kinetics, atmospheric transport of trace species; stratospheric ozone chemistry; tropospheric hydrocarbon chemistry; oxidizing power; nitrogen, oxygen, sulfur cycles; chemistry-climate-biosphere interactions; aerosols, smog, acid rain.

Spring 2021: EESC GU4924

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4924	001/10411	T Th 10:10am - 11:25am Online Only	Arlene Fiore	3	12/40

EESC GU4926 Principles of Chemical Oceanography. *3 points*.
Given in alternate years.

Prerequisites: Recommended preparation: one year of chemistry.
Factors controlling the concentration and distribution of dissolved chemical species within the sea. The physical chemistry of seawater, ocean circulation and mixing, gas exchange and biogeochemical processes interact to influence the distribution and fate of elements in the ocean. The course examines in some detail the two-way interaction between marine ecosystems and their chemical environment, and the implications of these interactions for distributions in the ocean of carbon, nutrients and trace metals.

Spring 2021: EESC GU4926

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4926	001/10412	T Th 1:10pm - 2:25pm Online Only	Robert Anderson	3	14/50

EESC GU4930 Earth's Oceans and Atmosphere. *3 points*.
Prerequisites: Recommended preparation: a good background in the physical sciences.
Physical properties of water and air. Overview of the stratification and circulation of Earth's ocean and atmosphere and their governing processes; ocean-atmosphere interaction; resultant climate system; natural and anthropogenic forced climate change.

Spring 2021: EESC GU4930

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4930	001/10413	T Th 1:10pm - 2:25pm Online Only	Arnold Gordon	3	5/30

EESC GU4937 Cenozoic Paleoceanography. *3 points*.
Given in alternate years. Enrollment limited to 20 students EESC (DEES) graduate students have priority..

Prerequisites: college-level geology helpful but not required.
Introduces the physical, chemical and biological processes that govern how and where ocean sediments accumulate. Major topics addressed are: modes of biogenic, terrigenous and authigenic sedimentation, depositional environments, pore fluids and sediment geochemistry, diagenesis, as well as biostratigraphy and sediment stratigraphic principles and methods. Second half of the semester focuses on major events in Cenozoic paleoceanogrpahy and paleoclimatology including orbital control of climate, long-term carbon cycle, extreme climate regimes, causes of ice ages in Earth's history, human evolution, El Niño evolution, and long-term sea level history.

Spring 2021: EESC GU4937

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4937	001/10414	T Th 10:10am - 11:25am Online Only	Maureen Raymo, Baerbel Hoenisch	3	9/20

Of Related Interest

Environmental Science (Barnard)	
EESC BC1001	Environmental Science I
EESC BC1011	Environmental Science I Lab
EESC BC3014	Field Methods in Environmental Science
EESC BC3016	Environmental Measurements
EESC BC3017	Environmental Data Analysis
EESC BC3025	Hydrology
EESC BC3033	Waste Management
EESC BC3050	Big Data with Python: Python for Environmental Analysis and Visualisation
EESC BC3200	Ecotoxicology
EESC BC3300	Workshop in Sustainable Development
Physics	
PHYS UN1018	Weapons of Mass Destruction

Generally Alternate Year Courses

EESC UN1001	Dinosaurs and the History of Life: Lectures and Lab
EESC UN1201	Environmental Risks and Disasters
EESC UN1401	Dinosaurs and the History of Life: Lectures
EESC UN3015	The Earth's Carbon Cycle
EESC GU4009	Chemical Geology
EESC GU4040	CLIM THERMODYN/ENERGY TRANSFER
EESC GU4085	GEODYNAMICS
EESC GU4113	INTRODUCTION TO MINERALOGY I
EESC GU4330	Introduction to Terrestrial Paleoclimate
EESC GU4223	SEDIMENTARY GEOLOGY
EESC GU4300	The Earth's Deep Interior
EESC GU4630	Air-sea interaction
EESC GU4701	Introduction to Igneous Petrology
EESC GU4835	Wetlands and Climate Change
EESC GU4885	The Chemistry of Continental Waters
EESC GU4887	Isotope Geology I
EESC GU4888	Stable Isotope Geochemistry

EESC GU4920	Paleoceanography
EESC GU4926	Principles of Chemical Oceanography
EESC GU4937	Cenozoic Paleoceanography
EESC GU4929	Mixing and Dispersion in the Ocean
EESC GU4949	Introduction to Seismology
EESC GR6111	Modern analytical methods in geochemistry
EESC GR6701	Igneous and metamorphic processes during the creation and evolution of the tectonic plates
EESC GR6810	The Carbon Cycle
EESC GR6901	Research Computing for the Earth Sciences
EESC GR6909	Advanced Time Series Analysis
EESC GR6920	Dynamics of Climate
EESC GR6921	Atmospheric Dynamics
EESC GR6922	Atmospheric Radiation
EESC GR6928	Tropical Meteorology
EESC GR6949	ADVANCED SEISMOLOGY I
EESC GR6930	Ocean Dynamics
EESC GR9500	SEM-PLANT PHYSIOLOGY & EC