

EARTH AND ENVIRONMENTAL SCIENCES

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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.

Climate System Science Major

The climate system science major is designed for students who are interested in how the past, present, and future climate system works *and* in solution strategies for the rapidly accelerating climate crisis. The overall goal is to establish the fundamental sciences at the core of the climate system, and to inspire solution-oriented analytical thinking and expertise. The flexible course structure combines geology, physics, biology, chemistry, and math with a core in climate system science and climate solution, justice, policy and communication courses. Sample tracks through the major in sea level change, decarbonization and modern climate link to the mission and applied centers of Columbia's Climate School. We believe that any admitted student has the potential to succeed in climate science.

Climate System Science majors begin with foundational courses in the climate system and introductory courses in global warming, oceanography or other relevant topics. Supporting courses include a grounding in calculus and natural sciences. Five climate core courses include both paleoclimate and modern climate requirements, as well as three other electives. Students pursue topics in climate solutions, policy, justice and communication in courses outside the sciences, in architecture, economics, political science or engineering. All climate system science majors are required to complete a capstone experience, which can include a field course or independent research project, typically at Lamont-Doherty Earth Observatory with guidance from a leading climate scientist.

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

Ryan Abernathey
 Nicholas Christie-Blick
 Joel E. Cohen
 Hugh Ducklow
 Sonya Dyhrman
 Peter Eisenberger
 Göran Ekström
 Pierre Gentine
 Steven L. Goldstein
 Arnold L. Gordon
 Kevin L. Griffin (Chair)
 Alex Halliday
 Sidney R. Hemming (Director of Graduate Studies)
 Bärbel Hönlisch
 Peter B. Kelemen
 Folarin Kolawole
 Galen McKinley
 Jerry F. McManus (Associate Chair)
 Faye McNeill
 William H. Menke
 John C. Mutter
 Meredith Nettles
 Paul E. Olsen
 Terry A. Plank (Director of Undergraduate Studies)
 Lorenzo M. Polvani
 G. Michael Purdy
 Maureen Raymo
 Christopher H. Scholz
 Adam H. Sobel
 Marc Spiegelman
 Martin Stute (Barnard)

Maya Tolstoy
 Renata Wentzcovich

Associate Professors

Jacqueline Austermann
 Roisin Commame
 Jonathan Kingslake

Assistant Professors

Folarin Kolawole
 Yves Moussallam

Adjunct Professors

Robert F. Anderson
 W. Roger Buck IV
 Denton Ebel
 John J. Flynn
 Arthur Lerner-Lam
 Alberto Malinverno
 Ronald L. Miller
 Dorothy M. Peteet
 Andrew Robertson
 Joerg M. Schaefer
 Christopher Small
 Andreas Thurnherr
 Felix Waldhauser
 Spahr C. Webb
 Gisela Winckler

Adjunct Associate Professors

Anne Bécél

Emeritus

Mark Cane
 Hugh Ducklow
 Arnold Gordon
 James Hays
 Paul Richards
 Lynn Sykes
 David Walker

Guidelines for all Earth Science, Environmental Science, and Climate System Science 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 # 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 Science, Environmental Science, & Climate System Science 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 ENVIRO SYST: CLIM SYST
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH

Students who wish to take both EESC UN2100 EARTH'S ENVIRO SYST: CLIM SYST and EESC UN2300 EARTH'S ENVIRO SYST: LIFE SYST 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
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Select one of the following three-course sequences:

CHEM UN1403 - CHEM UN1404 - PHYS UN1201	GENERAL CHEMISTRY I-LECTURES and GENERAL CHEMISTRY II-LECTURES 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	ENVR SCIENCE SENIOR SEMINAR and SENIOR SEMINAR
EESC BC3801 - EESC UN3901	ENVR SCIENCE SENIOR SEM II and 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 ENVIRO SYST: CLIM SYST
EESC UN2300	EARTH'S ENVIRO SYST: LIFE SYST
EESC UN3010	FIELD GEOLOGY
EESC BC3017	ENVIRONMENTAL DATA ANALYSIS
EESC GU4050	GLOBAL ASSMT-REMOTE SENSING
EESC GU4600	EARTH RESOURCES # SUSTAIN DEV
EESC GU4917	THE EARTH/HUMAN INTERACTIONS
EAAE 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 or EESC UN3201	Geochemistry for a Habitable Planet SOLID EARTH DYNAMICS
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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	INTRO TO GEOCHRONOLGY
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 AND CLIMATE

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	INTRO TO GEOCHRONOLGY
EESC GU4113	INTRODUCTION TO MINERALOGY I
EESC GU4701	Introduction to Igneous Petrology
EESC GU4885	CHEMISTRY OF CONTINENTAL WATERS
EESC GU4887	ISOTOPE GEOLOGY I
EESC GU4926	INTRO TO 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	INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4925	Principles of Physical Oceanography
EESC GU4926	INTRO TO 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 AND CLIMATE
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	INTRO 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	INTRO 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 Science, Environmental Science, & Climate System Science 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 ENVIRO SYST: CLIM SYST
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300	EARTH'S ENVIRO SYST: LIFE SYST

Supporting Mathematics and Science Courses

One semester of Calculus at the level of Calculus I or higher (3 credits)

MATH UN1101	CALCULUS I
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Select one of the following three-course sequences:

CHEM UN1403 - CHEM UN1404 - PHYS UN1201	GENERAL CHEMISTRY I-LECTURES and GENERAL CHEMISTRY II-LECTURES and GENERAL PHYSICS I
CHEM UN1403 - PHYS UN1201 - PHYS UN1202	GENERAL CHEMISTRY I-LECTURES and GENERAL PHYSICS I and GENERAL PHYSICS II
CHEM UN1403 - EEBB UN2001 - PHYS UN1201	GENERAL CHEMISTRY I-LECTURES and ENVIRONMENTAL BIOLOGY I and GENERAL PHYSICS I

Capstone Experience

EESC BC3800 or EESC BC3801	ENVR SCIENCE SENIOR SEMINAR ENVR SCIENCE SENIOR SEM II
EESC UN3901	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 ASSMT-REMOTE SENSING
EESC GU4600	EARTH RESOURCES # SUSTAIN DEV
EESC GU4917	THE 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 or EESC UN3201	Geochemistry for a Habitable Planet SOLID EARTH DYNAMICS
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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	

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	CHEMISTRY OF CONTINENTL WATERS
EESC GU4887	ISOTOPE GEOLOGY I
EESC GU4924	INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4888	Stable Isotope Geochemistry
EESC GU4926	INTRO TO CHEMICAL OCEANOGRAPHY

Hydrology

EESC GU4076	Geologic Mapping
EESC GU4835	Wetlands and Climate Change
EESC GU4885	CHEMISTRY OF CONTINENTL WATERS
EESC BC3025	HYDROLOGY

EAEE E3221

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

Major in Climate System Science

Please read [Guidelines for all Earth Science, Environmental Science, & Climate System Science Majors, Concentrators, and Special Concentrators](#) above.

The major in climate system science requires a minimum of 43.5 points, distributed as follows:

Foundational Courses

7.5 points minimum (2 courses):

Required:

EESC UN2100	EARTH'S ENVIRO SYST: CLIM SYST
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And any one of:

EESC UN1009	GLOBAL WARMING FOR GLOBAL LEADERS
EESC UN1030	OCEANOGRAPHY
EESC UN1201	Environmental Risks and Disasters
EESC UN1600	EARTH RESOURCES # SUSTAIN DEV
or EESC GU4600	EARTH RESOURCES # SUSTAIN DEV
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300	EARTH'S ENVIRO SYST: LIFE SYST
EESC UN2330	SCIENCE FOR SUSTAINABLE DEVPT

Supporting Courses

12 points minimum (4 courses):

One semester of Calculus at the level of Calculus I or higher:

MATH UN1101	CALCULUS I
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And any three courses:

PHYS UN1201	GENERAL PHYSICS I
PHYS UN1202	GENERAL PHYSICS II
CHEM UN1403	GENERAL CHEMISTRY I-LECTURES
CHEM UN1404	GENERAL CHEMISTRY II-LECTURES
EEEB UN2001	ENVIRONMENTAL BIOLOGY I
EESC UN2300	EARTH'S ENVIRO SYST: LIFE SYST

Climate System Core

15 points minimum (five courses):

Required: at least one Paleoclimate Course

EESC GU4235	SEA LEVEL CHANGE
EESC GU4330	Introduction to Terrestrial Paleoclimate
EESC GU4480	Paleobiology and Earth System History
EESC GU4920	PALEOCEANOGRAPHY
EESC GU4937	CENOZOIC PALEOCEANOGRAPHY

Required: at least one Modern Climate Course

EESC UN3109	CLIMATE PHYSICS
EESC GU4008	Introduction to Atmospheric Science
EESC GU4020	HUMANS # THE CARBON CYCLE
EESC GU4040	CLIM THERMODYN/ENERGY TRANSFER
EESC GU4925	Principles of Physical Oceanography
EESC GU4930	EARTH'S OCEANS # ATMOSPHERE

Could include: Other Climate System Course

EESC BC3109	Hydrology
EESC UN3101	Geochemistry for a Habitable Planet
EESC UN3201	SOLID EARTH DYNAMICS
EESC GU4220	GLACIOLOGY
EESC GU4835	Wetlands and Climate Change
EESC GU4885	CHEMISTRY OF CONTINENTL WATERS
EESC GU4923	Biological Oceanography
EESC GU4924	INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4926	INTRO TO CHEMICAL OCEANOGRAPHY

Could include one: Supporting EESC Course

EESC UN3400	COMPUTATIONAL EARTH SCIENCE
EESC GU4210	GEOPHYSICAL FLUID DYNAMICS
EESC GU4223	SEDIMENTARY GEOLOGY
EESC GU4230	CRUSTAL DEFORMATION
EESC GU4887	ISOTOPE GEOLOGY I
EESC GU4888	Stable Isotope Geochemistry

Climate Solutions, Justice, Policy and Communication

6 points minimum (any two courses below):

Solutions Courses

EESC BC3045	RESPONDING TO CLIMATE CHANGE (Barnard College)
ARCH UN3120	CITY, LANDSCAPE, # ECOLOGY
EAEE E2002	ALTERNATIVE ENERGY RESOURCES
EAEE E2100	A BETTER PLANET BY DESIGN
EAEE E4001	INDUST ECOLOGY-EARTH RESOURCES
EAEE E4002	ALTERNATIVE ENERGY RESOURCES
EAEE E4006	Field methods for environmental engineering
EAEE E4300	INTRO TO CARBON MANAGEMENT
EAEE E4302	CARBON CAPTURE
EAEE E4301	CARBON STORAGE
EAEE E4305	CO2 UTILIZATION AND CONVERSION
CIEE E3250	HYDROSYSTEMS ENGINEERING

MECE E4211	ENERGY SOURCES AND CONVERSION
SDEV GU4250	CLIMATE CHANGE: RESILIENCE # ADAPTATION
Climate Justice, Policy, Economics	
ANTH BC3932 CLIMATE CH./GLOB. MIGRATION/HUMAN RIGHTS (Barnard College)	
ANTH V3861	
ARCH UN3400	ENVIRONMENTAL VISUALIZATIONS OF NYC
ECON BC3039 ENVIRONMENTAL & NAT. RES. ECONOMICS (Barnard College)	
ECON BC3040 ENVIRONMENTAL LAW (Barnard College)	
ECON UN2257	THE GLOBAL ECONOMY
ECON GU4750	GLOBALIZATION # ITS RISKS
POLS UN3648	GOVERNING THE GLOBAL ECONOMY
POLS GU4814	GLOBAL ENERGY: SECURITY/GEOPOL
POLS GU4863	INTERNATIONAL POLITICAL ECONOMY OF DEVELOPING COUNTRIES
SDEV UN3355	CLIMATE CHANGE AND LAW
SDEV UN3360	DISASTERS AND DEVELOPMENT

Climate System Capstone

3 points minimum (one course):

EESC 3xxx Undergraduate Research Project (course is under development)

EESC UN3901 SENIOR SEMINAR (taken twice, in fall and spring)

or EESC BC3800 followed by EESC UN3901

Approved Field Course focused on the Climate System

~6 weeks, must be proposed and then approved by DUS

Concentration in Earth Science

Please read [Guidelines for all Earth Science, Environmental Science, & Climate System Science 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 ENVIRO SYST: CLIM SYST
or EESC UN2300	EARTH'S ENVIRO SYST: LIFE SYST
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 Science, Environmental Science, & Climate System Science 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 ENVIRO SYST: CLIM SYST
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300	EARTH'S ENVIRO SYST: LIFE SYST

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 Science, Environmental Science, & Climate System Science 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 ENVIRO SYST: CLIM SYST
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300	EARTH'S ENVIRO SYST: LIFE SYST

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 Science, Environmental Science, & Climate System Science 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
EESC UN2100	EARTH'S ENVIRO SYST: CLIM SYST
EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EEEB UN2002	ENVIRONMENTAL BIOLOGY II

Introductory Science (13 points)

Select one of the following chemistry sequences:

CHEM UN1403 - CHEM UN1404	GENERAL CHEMISTRY I-LECTURES and GENERAL CHEMISTRY II-LECTURES
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	CALC-BASED INTRO TO STATISTICS
BIOL BC2286	Statistics and Research Design
EEEB UN3005	INTRO-STAT-ECOLOGY # EVOL BIOL
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.

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Fall 2023

EESC UN1001 DINOSAURS AND HISTORY OF LIFE. 4.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Given in alternate years.

Prerequisites: Recommended preparation: basic high school science and math.

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? ... or did they? A basic introduction to the historical sciences and the interface between geology and biology

Fall 2023: EESC UN1001

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1001	001/13223	M W 1:10pm - 2:25pm 301 Uris Hall	Paul Olsen	4.00	20/40
EESC 1001	001/13223	M 4:10pm - 7:00pm 603 Schermerhorn Hall	Paul Olsen	4.00	20/40

EESC UN1030 OCEANOGRAPHY. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Enrollment limited to 160.

Explore the geology of the sea floor, understand what drives ocean currents and how ocean ecosystems operate. Case studies and discussions centered on ocean-related issues facing society

Fall 2023: EESC UN1030

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1030	001/13126	T Th 11:40am - 12:55pm 501 Northwest Corner	Baerbel Hoenisch	3.00	146/160

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 2023: EESC UN1201

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1201	001/13127	T Th 10:10am - 11:25am 330 Uris Hall	Goran Ekstrom	3	41/60

EESC UN1401 DINOSAUR # HISTORY OF LIFE-LEC. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: Recommended preparation: basic high school science and math.

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? ... or did they? A basic introduction to the historical sciences and the interface between geology and biology

Fall 2023: EESC UN1401

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1401	001/13128	M W 1:10pm - 2:25pm 301 Uris Hall	Paul Olsen	3.00	58/100

EESC UN1600 EARTH RESOURCES # SUSTAIN DEV. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: none; high school chemistry recommended.

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 2023: EESC UN1600

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1600	001/13129	T Th 1:10pm - 2:25pm 301 Uris Hall	Peter Kelemen	3.00	91/200

EESC UN2100 EARTH'S ENVIRO SYST: CLIM SYST. 4.50 points.

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

Fall 2023: EESC UN2100

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2100	001/13062	T Th 10:10am - 11:25am 603 Schermerhorn Hall	Jerry McManus, Suzana De Camargo	4.50	48/50
EESC 2100	001/13062	T 4:10pm - 7:00pm 603 Schermerhorn Hall	Jerry McManus, Suzana De Camargo	4.50	48/50

Spring 2024: EESC UN2100

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2100	001/12424	T Th 10:10am - 11:25am 603 Schermerhorn Hall	Mingfang Ting, Gisela Winckler	4.50	44/50
EESC 2100	001/12424	T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall	Mingfang Ting, Gisela Winckler	4.50	44/50
EESC 2100	002/16962	T Th 1:10pm - 2:25pm 603 Schermerhorn Hall	Michela Biasutti, Jennifer Middleton	4.50	14/25
EESC 2100	002/16962	W 4:10pm - 7:00pm 555 Ext Schermerhorn Hall	Michela Biasutti, Jennifer Middleton	4.50	14/25

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.

Recommended preparation: high school chemistry and physics; and one semester of college science. 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

Fall 2023: EESC UN2200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2200	001/13130	T Th 1:10pm - 2:25pm 313 Fayerweather	John Mutter, Jonathan Kingslake	4.50	70/80
EESC 2200	001/13130	Th 4:10pm - 7:00pm 603 Schermerhorn Hall	John Mutter, Jonathan Kingslake	4.50	70/80

Spring 2024: EESC UN2200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2200	001/12441	T Th 2:40pm - 3:55pm 603 Schermerhorn Hall	Steven Goldstein, Sidney Hemming	4.50	59/55
EESC 2200	001/12441	T 4:10pm - 7:00pm 603 Schermerhorn Hall	Steven Goldstein, Sidney Hemming	4.50	59/55

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 2023: EESC UN2330

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2330	001/13131	T Th 2:40pm - 3:55pm 501 Northwest Corner	John Mutter, Jenna Lawrence	3	108/120

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 2023: EESC UN3101

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3101	001/13133	T Th 11:40am - 12:55pm 603 Schermerhorn Hall	Terry Plank	3	40/45

EESC UN3901 SENIOR SEMINAR. 3.00 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

Fall 2023: EESC UN3901

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3901	011/14060	Th 4:10pm - 6:00pm 530 Altschul Hall	Jerry McManus, Sidney Hemming	3.00	9/50

Spring 2024: EESC UN3901

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3901	001/12520	Th 4:10pm - 6:00pm 202 Altschul Hall	Sidney Hemming, Jacqueline Austermann, Elizabeth Cook	3.00	20/50

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 2023: EESC GU4008

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4008	001/13134	T 4:10pm - 6:40pm 417 Schermerhorn Hall	Lorenzo Polvani	3	43/47

EESC GU4050 GLOBAL ASSMT-REMOTE SENSING. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Enrollment limited to 24. Priority given to graduate students in the natural sciences and engineering.

Prerequisites: Course Cap 20 students. Priority given to graduate students in the natural sciences and engineering. Advanced level undergraduates may be admitted with the instructor's permission. Calculus I and Physics I & II are required for undergraduates who wish to take this course.

Prerequisites: Course Cap 20 students. Priority given to graduate students in the natural sciences and engineering. Advanced level undergraduates may be admitted with the instructors permission. Calculus I and Physics I # II are required for undergraduates who wish to take this course. General introduction to fundamentals of remote sensing; electromagnetic radiation, sensors, interpretation, quantitative image analysis and modeling. Example applications in the Earth and environmental sciences are explored through the analysis of remote sensing imagery in a state-of-the-art visualization laboratory

Fall 2023: EESC GU4050

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4050	001/13135	Th 5:40pm - 6:55pm 417 Schermerhorn Hall	Christopher Small	3.00	12/20
EESC 4050	001/13135	F 9:00am - 10:45am 558 Ext Schermerhorn Hall	Christopher Small	3.00	12/20

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

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

Fall 2023: EESC GU4113

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4113	001/13065	T 6:30pm - 8:30pm 506 Schermerhorn Hall	Yves Moussallam	4.00	6/15
EESC 4113	001/13065	T Th 8:40am - 9:55am 506 Schermerhorn Hall	Yves Moussallam	4.00	6/15

EESC GU4330 Introduction to Terrestrial Paleoclimate. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Given in alternate years.

An overview of the archives in which evidence of terrestrial paleoclimate is preserved, the approaches to developing and applying proxies of climate from these archives, approaches for constraining the time represented by the information, and interpretations that have been developed from such archives. Important archives to be included are ice cores, caves, wetlands, lakes, trees, and moraines. The time interval covered will be mostly the last few tens of thousand years, and chronometers based on radiocarbon, U-series and surface exposure dating will be presented. The course will consist of a formal lecture on one day and a recitation on the second day which will emphasize examples and problem solving.

EESC GU4600 EARTH RESOURCES # SUSTAIN DEV. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: none; high school chemistry recommended.

Prerequisites: none; high school chemistry recommended. This course is open to graduate students, and juniors and seniors within DEES, Sus Dev, Engineering, Chemistry, Physics, and APAM - or with the instructors permission. 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 2023: EESC GU4600

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4600	001/13232	T Th 1:10pm - 2:25pm 301 Uris Hall	Peter Kelemen	3.00	20/30

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 GU4925 Principles of Physical Oceanography. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: Recommended preparation: a solid background in mathematics, physics, and chemistry.

Physical properties of seawater, water masses and their distribution, sea-air interaction influence on the ocean structure, basic ocean circulation pattern, relation of diffusion and advection with respect to distribution of ocean properties, ocean tides and waves, turbulence, and introduction to ocean dynamics.

Fall 2023: EESC GU4925

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4925	001/13138	T Th 8:40am - 9:55am 417 Schermerhorn Hall	Andreas Thurnherr	3	18/25

EESC GU4949 Introduction to Seismology. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: advanced calculus and general physics, or the instructor's permission.

Methods and underpinnings of seismology including seismogram analysis, elastic wave propagation theory, earthquake source characterization, instrumentation, inversion of seismic data to infer Earth structure.

Spring 2024

EESC UN1009 GLOBAL WARMING FOR GLOBAL LEADERS. 3.00 points.

Global Warming will dominate civic discourse and inform economic, social, and governmental policies throughout the 21st century, in all walks of life. This course will cover the basics of climate science, anthropogenic global warming, proposed solutions and policy challenges facing society in response to our changing planet. This course will increase your confidence and ability to engage in public discourse on the subject of climate change, climate change solutions, and public policy concerning our collective future

Spring 2024: EESC UN1009

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1009	001/12410	T Th 11:40am - 12:55pm Cin Alfred Lerner Hall	Maureen Raymo, Baerbel Hoenisch	3.00	200/200
EESC 1009	AU1/18951	T Th 11:40am - 12:55pm Othr Other	Maureen Raymo, Baerbel Hoenisch	3.00	5/5

EESC UN1010 GEOLO EXCUR TO DEATH VALLEY,CA. 2.00 points.

Enrollment limited to 20.

The trip is restricted to first-years and sophomores from Columbia College/General Studies, Barnard College, and the School of Engineering and Applied Science. Early application is advised, and no later than November 12. A spring-break excursion focused on the geology of Death Valley and adjacent areas of the eastern California desert. Discussion sessions ahead of the trip provide necessary background. Details at: <https://eesc.columbia.edu/content/eesc-un1010>

Spring 2024: EESC UN1010

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 1010	001/12416	F 5:30pm - 7:00pm 558 Ext Schermerhorn Hall	Folarin Kolawole	2.00	20/20

EESC UN2100 EARTH'S ENVIRO SYST: CLIM SYST. 4.50 points.

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

Fall 2023: EESC UN2100

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2100	001/13062	T Th 10:10am - 11:25am 603 Schermerhorn Hall	Jerry McManus, Suzana De Camargo	4.50	48/50
EESC 2100	001/13062	T 4:10pm - 7:00pm 603 Schermerhorn Hall	Jerry McManus, Suzana De Camargo	4.50	48/50

Spring 2024: EESC UN2100

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2100	001/12424	T Th 10:10am - 11:25am 603 Schermerhorn Hall	Mingfang Ting, Gisela Winckler	4.50	44/50
EESC 2100	001/12424	T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall	Mingfang Ting, Gisela Winckler	4.50	44/50
EESC 2100	002/16962	T Th 1:10pm - 2:25pm 603 Schermerhorn Hall	Michela Biasutti, Jennifer Middleton	4.50	14/25
EESC 2100	002/16962	W 4:10pm - 7:00pm 555 Ext Schermerhorn Hall	Michela Biasutti, Jennifer Middleton	4.50	14/25

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.

Recommended preparation: high school chemistry and physics; and one semester of college science. 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

Fall 2023: EESC UN2200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2200	001/13130	T Th 1:10pm - 2:25pm 313 Fayerweather	John Mutter, Jonathan Kingslake	4.50	70/80
EESC 2200	001/13130	Th 4:10pm - 7:00pm 603 Schermerhorn Hall	John Mutter, Jonathan Kingslake	4.50	70/80

Spring 2024: EESC UN2200

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2200	001/12441	T Th 2:40pm - 3:55pm 603 Schermerhorn Hall	Steven Goldstein, Sidney Hemming	4.50	59/55
EESC 2200	001/12441	T 4:10pm - 7:00pm 603 Schermerhorn Hall	Steven Goldstein, Sidney Hemming	4.50	59/55

EESC UN2300 EARTH'S ENVIRO SYST: LIFE SYST. 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 reinstated.

Prerequisites: high school algebra. Recommended preparation: high school chemistry and physics.

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, data analysis, and modeling. REQUIRED LAB: EESC UN2310. Students will be expected to choose a lab section during the first week of class from the options listed in the Directory of Classes. Co-meets with EEEB 2002

Spring 2024: EESC UN2300

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 2300	001/12449	M W 11:40am - 12:55pm 313 Fayerweather	Paul Olsen, Matthew Palmer, Sonya Dyhrman	4.50	50/50

EESC UN3010 FIELD GEOLOGY. 3.00 points.

Fee: to be determined.

The centerpiece of this course is a geological field trip during Spring Break in Barbados. The class will meet weekly 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, local 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 we will see) the class will go snorkeling. In order to observe the effects of cave formation and water flow in limestone terrains the class will participate in an extensive visit to a cave. The class will also participate in an exercise in geological mapping of a series of coral reef terraces. Priority is given to junior and senior majors and concentrators in Earth Science or Environmental Science at Columbia College and the School of General Studies, and Barnard College Environmental Science majors and minors. Others (non-DEES majors and non-Barnard Environmental Science students) may also be allowed to enroll if space permits. All students need permission of the instructor. Students who sign up will be put on a waitlist and will be considered after contacting the instructor

Spring 2024: EESC UN3010

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3010	001/12475	T 7:30pm - 9:20pm 603 Schermerhorn Hall	Steven Goldstein, Sidney Hemming	3.00	19/20

EESC UN3109 CLIMATE PHYSICS. 3.00 points.

This is a calculus-based treatment of climate system physics and the mechanisms of anthropogenic climate change. By the end of this course, students will understand: how solar radiation and rotating fluid dynamics determine the basic climate state, mechanisms of natural variability and change in climate, why anthropogenic climate change is occurring, and which scientific uncertainties are most important to estimates of 21st century change. This course is designed for undergraduate students seeking a quantitative introduction to climate and climate change science. EESC V2100 (Climate Systems) is not a prerequisite, but can also be taken for credit if it is taken before this course

Spring 2024: EESC UN3109

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3109	001/12499	T Th 10:10am - 11:25am 555 Ext Schermerhorn Hall	Adam Sobel	3.00	15/25

EESC UN3201 SOLID EARTH DYNAMICS. 3.00 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.

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 instructors 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 2024: EESC UN3201

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3201	001/12507	T Th 11:40am - 12:55pm 417 Schermerhorn Hall	Meredith Nettles	3.00	19/30

EESC UN3901 SENIOR SEMINAR. 3.00 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

Fall 2023: EESC UN3901

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3901	011/14060	Th 4:10pm - 6:00pm 530 Altschul Hall	Jerry McManus, Sidney Hemming	3.00	9/50

Spring 2024: EESC UN3901

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 3901	001/12520	Th 4:10pm - 6:00pm 202 Altschul Hall	Sidney Hemming, Jacqueline Austermann, Elizabeth Cook	3.00	20/50

EESC GU4090 INTRO TO GEOCHRONOLGY. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: one term of college-level calculus, and solid Earth system science or its equivalent.

An overview of approaches to estimating ages of sedimentary sequences and events in Earth history-to be co listed at Stony Brook and Rutgers. Intended for students with good backgrounds in the physical sciences, who want to use geochronological techniques in their studies. Because of the hands-on nature of geochronology and thermochronology, we are going to run the course as a series of 5 workshops held on Saturdays (possibly a Sunday depending on scheduling)

Spring 2024: EESC GU4090

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4090	001/12529	Sa 10:00am - 4:00pm 603 Schermerhorn Hall	Sidney Hemming	3.00	18/20

EESC GU4210 GEOPHYSICAL FLUID DYNAMICS. 3.00 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.

Prerequisites: *APMA E3101*, *APMA E3201* or equivalents and *APPH E4200* or equivalent or the instructors 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 2024: EESC GU4210

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4210	001/12539	T Th 8:40am - 9:55am 555 Ext Schermerhorn Hall	Dhruv Balwada	3.00	17/35

EESC GU4300 THE EARTH'S DEEP INTERIOR. 3.00 points.

Prerequisites: Vector calculus, differential equations, one year of college physics (mechanics, electromagnetism, waves)

An overview of the geophysical study of the Earth, drawing upon geodesy, gravity, seismology, thermal studies, geomagnetism, materials science, and some geochemistry. Covers the principal techniques by which discoveries have been made, and are made, in deep Earth structure. Describes fundamental properties and features of the crust, mantle, and core

Spring 2024: EESC GU4300

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4300	001/12544	T Th 10:10am - 11:25am 506 Schermerhorn Hall	Goran Ekstrom	3.00	9/30

EESC GU4560 THE ECOLOGY OF TREELINE IN A CHANGING CLIMATE.**3.00 points.**

Prerequisites: Introductory Biology. Earth Science and one course in ecology recommended. Treelines are the boundaries between forests and low stature alpine and tundra vegetation, thought to be controlled by climate and therefore likely to respond to climate change. In 1807 Alexander von Humboldt and Aimé Bonpland described treeline as a global phenomenon and a bioclimatological reference that all other vegetation could be referenced against. Despite being clearly linked to climate, the mechanisms that control treeline formation and persistence remain an active area of scientific research and debate. The lack of a complete mechanistic understanding of how climate controls the location of treeline opens the important question of how treeline will respond to climate change. Furthermore, while physical site characteristics determine the potential location of treeline, trees may be absent for a variety of factors, complicating the predicted ecosystem response to a changing climate. These factors include local peculiarities of the environment, a regional lack of capable species, or a multitude of disturbances, including those caused by humans. This course is focused on the ecology treeline in light of global climate change and will provide students with a foundational understanding of fundamental ecological concepts as they pertain to this important ecological boundary between ecosystems and biomes. In addition, students will learn to (1) find, read, and discuss the primary scientific literature, and (2) communicate their findings via written, oral, and audio-visual formats. Topics include ecophysiology, population ecology, community ecology, biogeochemistry and ecosystem ecology

Spring 2024: EESC GU4560

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4560	001/12547	T Th 11:40am - 12:55pm 506 Schermerhorn Hall	Kevin Griffin	3.00	20/25

EESC GU4885 CHEMISTRY OF CONTINENTAL WATERS. 3.00 points.

Given in alternate years.

Prerequisites: Recommended preparation: a solid background in basic chemistry.

Prerequisites: Recommended preparation: a solid background in basic chemistry. Introduction to geochemical cycles involving the atmosphere, land, and biosphere; chemistry of precipitation, weathering reactions, rivers, lakes, estuaries, and groundwaters; students are introduced to the use of major and minor ions as tracers of chemical reactions and biological processes that regulate the chemical composition of continental waters

Spring 2024: EESC GU4885

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4885	001/12552	T Th 11:40am - 12:55pm 555 Ext Schermerhorn Hall	Robert Anderson	3.00	26/30

EESC GU4920 PALEOCEANOGRAPHY. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: Compliments GU4937 Cenozoic Paleoclimatology, intended as part of a sequence with GU4330 Terrestrial Paleoclimatology. For undergrads, UN2100 Earth System: Climate or equivalent, or permission of instructor

Prerequisites: Compliments GU4937 Cenozoic Paleoclimatology, intended as part of a sequence with GU4330 Terrestrial Paleoclimatology. For undergrads, UN2100 Earth System: Climate or equivalent, or permission of instructor The course examines the ocean's response to external climatic forcing such as solar luminosity and changes in the Earth's orbit, and to internal influences such as atmospheric composition, using deep-sea sediments, corals, ice cores and other paleoceanographic archives. A rigorous analysis of the assumptions underlying the use of climate proxies and their interpretations will be presented. Particular emphasis will be placed on amplifiers of climate change during the alternating ice ages and interglacial intervals of the last few million years, such as natural variations in atmospheric greenhouse gases and changes in deep water formation rates, as well as mechanisms of rapid climate change during the late Pleistocene. The influence of changes in the Earth's radiation distribution and boundary conditions on the global ocean circulation, Asian monsoon system and El Nino/Southern Oscillation frequency and intensity, as well as interactions among these systems will be examined using proxy data and models. This course complements W4937 Cenozoic Paleoclimatology and is intended as part of a sequence with W4330 Terrestrial Paleoclimatology for students with interests in Paleoclimatology

Spring 2024: EESC GU4920

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4920	001/12556	T Th 10:10am - 11:25am 417 Schermerhorn Hall	Jerry McManus	3.00	31/30

EESC GU4924 INTRO TO ATMOSPHERIC CHEMISTRY. 3.00 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.

Prerequisites: Physics W1201, Chemistry W1403, Calculus III, or equivalent or the instructors permission. EESC W2100 preferred. 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, carbon, mercury cycles; chemistry-climate-biosphere interactions; aerosols, smog, acid rain

Spring 2024: EESC GU4924

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4924	001/12560	T Th 11:40am - 12:55pm 603 Schermerhorn Hall	Roisin Commane	3.00	13/30

EESC GU4947 PLATE TECTONICS AND CLIMATE. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

Prerequisites: course in solid earth geology or geophysics; solid background in math and physics

What produced the change from the hothouse to the ice house Earth in the last ~60 million years? What caused earlier ice ages and huge swings in sea level that covered so much of the continents with marine sediments? The possible answers, from weathering of rocks during periods of enhanced mountain building to changes in the rate of CO₂ release at mid-ocean ridges, all involve plate tectonics. We review the development of the plate tectonic theory, including role Columbia researchers played in making the break-throughs that first confirmed the theory. We will discuss ideas about what might control plate motions on Earth as well as what we know about different kinds of tectonics on other planets. Researchers working on cutting-edge observations and models relating tectonics and climate will be invited to air their views to the class

Spring 2024: EESC GU4947

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
EESC 4947	001/12564	T Th 2:40pm - 3:55pm 555 Ext Schermerhorn Hall	W Buck	3.00	15/40

EESC GR9910 SEM IN ATMOSPHERIC SCIENCE. 1.00-3.00 points.

May be repeated for up to 10 points of credit.

Prerequisites: the instructor's permission.

Prerequisites: the instructors permission. Current research developments in atmospheric sciences including tropical climate variability, stratospheric dynamics, atmospheric chemistry, remote sensing of the Earth's atmosphere, and global climate modeling

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
EESC BC3200	Ecotoxicology
EESC BC3300	WORKSHOP SUSTAINABLE DEVEL

Physics

PHYS UN1018	WEAPONS OF MASS DESTRUCTION
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Generally Alternate Year Courses

EESC UN1001	DINOSAURS AND HISTORY OF LIFE
EESC UN1201	Environmental Risks and Disasters
EESC UN1401	DINOSAUR # HISTORY OF LIFE-LEC
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 Paleoclimatology
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	CHEMISTRY OF CONTINENTL WATERS
EESC GU4887	ISOTOPE GEOLOGY I
EESC GU4888	Stable Isotope Geochemistry
EESC GU4920	PALEOCEANOGRAPHY
EESC GU4926	INTRO TO 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