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.
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 GENERAL CHEMISTRY I-LECTURES and GENERAL CHEMISTRY II-LECTURES and General Physics I
- CHEM UN1403 GENERAL CHEMISTRY I-LECTURES and General Physics I and General Physics II
- CHEM UN1403 GENERAL CHEMISTRY I-LECTURES and General Physics I

Capstone Experience
Select one of the following:
- EESC BC3800 Senior Research Seminar and Environmental Science Senior Seminar
- EESC BC3801 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

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

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 GU4900 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 Paleoenography
- EESC GU4924 Introduction to Atmospheric Chemistry
- EESC GU4925 Principles of Physical Oceanography
- EESC GU4926 Principles of Chemical Oceanography
Earth and Environmental Sciences

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 Paleogeography
- 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 UN403 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: Paleogeography
- EESC GU4924: Introduction to Atmospheric Chemistry
- EESC GU4925: Principles of Physical Oceanography
- EESC GU4937: Cenozoic Paleogeography

**Paleontology**

- EESC GU4223: SEDIMENTARY GEOLOGY
- EESC GU4550: Plant Ecophysiology
- EESC GU4920: Paleogeography
- EESC GU4924: Introduction to Atmospheric Chemistry
- EESC GU4937: Cenozoic Paleogeography

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: GENERAL CHEMISTRY I-LECTURES and General Chemistry I
- CHEM UN1404: GENERAL CHEMISTRY II-LECTURES and General Chemistry II
- PHYS UN1201: Introduction to Physics I
- CHEM UN1403: GENERAL CHEMISTRY I-LECTURES and General Chemistry I
- PHYS UN1202: Introduction to Physics II and General Physics II

**Capstone Experience**

- EESC BC3800: 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
- 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
- EAE 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: The Chemistry of Continental Waters
- EESC GU4887: Isotope Geology I
- EESC GU4924: Introduction to Atmospheric Chemistry
- EESC GU4926: Principles of Chemical Oceanography
- EESC UN3010: Field Geology
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**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN2100</td>
<td>Earth's Environmental Systems: The Climate System</td>
</tr>
<tr>
<td>or EESC UN2300</td>
<td>Earth's Environmental Systems: The Life System</td>
</tr>
<tr>
<td>EESC UN2200</td>
<td>EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH</td>
</tr>
</tbody>
</table>

**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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN3101</td>
<td>Geochemistry for a Habitable Planet</td>
</tr>
<tr>
<td>or EESC UN3201</td>
<td>Solid Earth Dynamics</td>
</tr>
</tbody>
</table>

One additional course selected 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**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN2100</td>
<td>Earth's Environmental Systems: The Climate System</td>
</tr>
</tbody>
</table>

**Introductory Environmental Science (13.5 points)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN2100</td>
<td>Earth's Environmental Systems: The Climate System</td>
</tr>
<tr>
<td>EESC UN2200</td>
<td>EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH</td>
</tr>
<tr>
<td>EESC UN2300</td>
<td>Earth's Environmental Systems: The Life System</td>
</tr>
</tbody>
</table>

**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)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEEB UN2001</td>
<td>Environmental Biology I: Elements to Organisms</td>
</tr>
<tr>
<td>EESC UN2100</td>
<td>Earth’s Environmental Systems: The Climate System</td>
</tr>
<tr>
<td>EESC UN2200</td>
<td>EARTH’S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH</td>
</tr>
<tr>
<td>EEEB UN2002</td>
<td>Environmental Biology II: Organisms to the Biosphere</td>
</tr>
</tbody>
</table>

Introductory Science (13 points)

Select one of the following chemistry sequences:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM UN1403</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
</tr>
<tr>
<td>CHEM UN1404</td>
<td>and GENERAL CHEMISTRY II-LECTURES</td>
</tr>
<tr>
<td>CHEM UN1604</td>
<td>2ND TERM GEN CHEM (INTENSIVE)</td>
</tr>
<tr>
<td>CHEM UN2507</td>
<td>and Intensive General Chemistry Laboratory</td>
</tr>
</tbody>
</table>

One term of statistics such as the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT UN1101</td>
<td>Introduction to Statistics</td>
</tr>
<tr>
<td>STAT UN1201</td>
<td>Calculus-Based Introduction to Statistics</td>
</tr>
<tr>
<td>BIOL BC2286</td>
<td>Statistics and Research Design</td>
</tr>
<tr>
<td>EEEB UN3005</td>
<td>Introduction to Statistics for Ecology and Evolutionary Biology</td>
</tr>
<tr>
<td>EEEB UN3087</td>
<td>Conservation Biology</td>
</tr>
</tbody>
</table>

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 the interface between geology and biology.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC 1001</td>
<td>Dinosaurs and the History of Life: Lectures and Lab.</td>
</tr>
<tr>
<td>EESC 1001</td>
<td>001/14067 M W 1:10pm - 2:25pm 501 Schermerhorn Hall</td>
</tr>
<tr>
<td>EESC 1001</td>
<td>001/14067 M 4:10pm - 7:00pm 603 Schermerhorn Hall</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC 1201</td>
<td>Environmental Risks and Disasters</td>
</tr>
<tr>
<td>EESC 1201</td>
<td>001/12770 M W 10:10am - 11:25am 413 Kent Hall</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC 1401</td>
<td>Dinosaurs and the History of Life: Lectures</td>
</tr>
<tr>
<td>EESC 1401</td>
<td>001/14068 M W 1:10pm - 2:25pm 501 Schermerhorn Hall</td>
</tr>
<tr>
<td>EESC 1401</td>
<td>001/14068 M 4:10pm - 7:00pm 603 Schermerhorn Hall</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC 1600</td>
<td>001/12771</td>
<td>T Th 1:10pm - 2:25pm 309 Havemeyer Hall</td>
<td>Peter Kelemen</td>
<td>3</td>
<td>112/150</td>
</tr>
</tbody>
</table>

EESC UN2100 Earth's Environmental Systems: The Climate System. 4.5 points.
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.

Fall 2021: EESC UN2100

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC 2100</td>
<td>001/12773</td>
<td>T Th 10:10am - 11:25am 603 Schermerhorn Hall</td>
<td>Jerry McManus, Suzana De Camargo</td>
<td>4.5</td>
<td>50/50</td>
</tr>
<tr>
<td>EESC 2100</td>
<td>001/12773</td>
<td>T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall</td>
<td>Jerry McManus, Suzana De Camargo</td>
<td>4.5</td>
<td>50/50</td>
</tr>
</tbody>
</table>

Spring 2022: EESC UN2100

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<thead>
<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC 2100</td>
<td>001/11915</td>
<td>T Th 10:10am - 11:25am 603 Schermerhorn Hall</td>
<td>Robert Pincus, Michela Biasutti, Jerry McManus</td>
<td>4.5</td>
<td>42/50</td>
</tr>
<tr>
<td>EESC 2100</td>
<td>001/11915</td>
<td>T 4:10pm - 7:00pm 603 Schermerhorn Hall</td>
<td>Robert Pincus, Michela Biasutti, Jerry McManus</td>
<td>4.5</td>
<td>42/50</td>
</tr>
</tbody>
</table>
and other essential methodological aspects.

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.

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.

EESC UN3101 Geochernistry for a Habitable Planet. 3 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.

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 geochronological analysis, 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.
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.

EESC UN3901

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<tr>
<td>EESC 3901</td>
<td>001/12777</td>
<td>Th 4:10pm - 6:00pm 530 Altschul Hall</td>
<td>Spahr Webb, Roisin Commane</td>
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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.

EESC GU4008

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<td>001/12778</td>
<td>Th 4:10pm - 6:40pm 214 Seeley W Mudd Building</td>
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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.

EESC GU4050 Global Assessment and Monitoring Using Remote Sensing. 3 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.
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.

EESC GU4050

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<tr>
<td>EESC 4050</td>
<td>001/12780</td>
<td>Th 5:40pm - 6:55pm 417 Schermerhorn Hall</td>
<td>Christopher Small</td>
<td>3</td>
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<tr>
<td>EESC 4050</td>
<td>001/12780</td>
<td>F 9:00am - 10:45am 555 Ext Schermerhorn Hall</td>
<td>Christopher Small</td>
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</table>
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.

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 organizational 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.

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.

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.

EESC GU4917 Earth/Human Interactions. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Enrollment limited to 20. Priority given to senior natural and social science majors, then graduate students.

Based upon the most current understanding of our planet and our impact on it and how we make decisions about the threats we face, a new knowledge-based “green” framework is developed for our relationship to our planet and to each other as well as its general implications for human stewardship of our planet and meeting the needs of 8 billion humans. This new framework is explored using case studies, class participation, and term papers on specific current scientific and policy issues like global warming, renewable energy, carbon dioxide removal and their impact on the sustainability and resilience of our planet and ourselves

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.
Spring 2022

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.

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

EESC UN2100 Earth’s Environmental Systems: The Climate System. 4.5 points.
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.

Fall 2021: EESC UN2100

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Spring 2022: EESC UN2100

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<td>T Th 10:10am - 11:25am</td>
<td>Robert Pincus, Michela Biasutti, Jerry McManus</td>
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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.

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.

* Co-meets with EEEB 2002

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.

EESC UN3114 Climate Impacts on Humans in NYC. 3.00 points.

How has climate shaped the history and development of NYC? How do climate and climate change affect our lives today? How will climate change affect our lives tomorrow? Variations in climate and weather have been major sources of risk and opportunity for humanity long before the industrial revolution began warming the planet. The growing impacts of climate change on human civilization over recent decades have turned attention from the future of our climate to the present. In this course, we investigate how the climate system intersects and interacts with the complex human system of NYC. The trajectory of this course will be set by the drafting of a final paper which will be done in small pieces throughout the semester. The first few weeks of the course will include lectures, activities, and assignments that will guide the selection of a specific climate impact for NYC and the formation of a research question for your final paper. This initial research question will then guide the majority of your assignments for the rest of the semester. Using this question, the five major sections of a scientific paper to structure the schedule for the remainder of the course: Introduction, Data, Methods, Results, and Conclusions

Spring 2022: EESC UN3114 Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 3114 001/14402 T Th 2:40pm - 3:55pm 558 Ext Schermerhorn Hall Nathan Lenssen 3.00 13/15
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 2022: EESC UN3201

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<td>Meredith Nettles</td>
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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.

Fall 2021: EESC UN3901

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Spring 2022: EESC UN3901

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EESC GU4009 CHEMICAL GEOLOGY. 3.00 points.
Given in alternate years.
Prerequisites: physical chemistry or the instructor's permission.
This course will examine geological problems from a standpoint of thermodynamic and kinetic theory. Theoretical thermodynamic concepts will be used to derive the crystallization depth and temperature of metamorphic and magmatic minerals, describe the solubility of volatile species in magmas, predict the composition of volcanic gas mixtures, model the nucleation and growth of crystals and bubbles in a melt and determine the chemical interaction between water and rock at the Earth's surface. Kinetic treatments on the diffusion of heat and matter through crystals and melts will be used to constrain the timing of geological processes. Recommended preparation: Knowledge of mathematics at the level of partial differential equations; mineralogy (EESC 4113); and petrology (EESC 4701); or permission of the instructor.

Spring 2022: EESC GU4009

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<td>Yves Moussallam</td>
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EESC GU4300 The Earth's Deep Interior. 3 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 2022: EESC GU4300

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EESC GU4885 The Chemistry of Continental Waters. 3 points.
Given in alternate years.
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 2022: EESC GU4885

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<td>Robert Anderson</td>
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EESC GU4920 Paleooceanography. 3 points.
CC/BS: Partial Fulfillment of Science Requirement
Given in alternate years.
Prerequisites: Compliments GU4937 Cenozoic Paleooceanography, intended as part of a sequence with GU4330 Terrestrial Paleoclimat. 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 intensity, as well as interactions among these systems will be examined using proxy data and models. This course complements W4937 Cenozoic Paleoeceanography and is intended as part of a sequence with W4330 Terrestrial Paleoclimat for students with interests in Paleoclimate.

Spring 2022: EESC GU4920

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<td>Jerry McManus</td>
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Earth and Environmental Sciences

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 2022: EESC GU4930
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 4930 001/11964 T Th 1:10pm - 2:25pm 417 Schermerhorn Hall Arnold Gordon 3 12/30

EESC GU4947 PLATE TECTONICS. 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
Prerequisites: course in solid earth geology or geophysics; one year of general physics Plate tectonics is the foundation of our understanding of all Earth processes including the climate system. This course will focus on four aspects of the development of the plate tectonic theory: the history of science concerning ideas about the evolution of the Earth including accounts of the plate tectonic revolution from the point of view of the people, many at Columbia, who led the way, geophysical methods such as the magnetic, gravity, heat flow and seismic tools and techniques that sparked, and continue to advance, the revolution; unresolved tectonic questions including the generation of mountain belts, the splitting of continents and the formation of large igneous provinces; climatic effects of plate tectonics such as changes in sea level and planetary albedo, the erosion and weathering of mountains, volcanic CO2 release and subduction recycling of carbon.

Spring 2022: EESC GU4947
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 4947 001/16957 T Th 1:10pm - 2:25pm 506 Schermerhorn Hall W Buck 3.00 8/40

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 Paleogeography
EESC GU4926 Principles of Chemical Oceanography
EESC GU4937 Cenozoic Paleogeography
EESC GU4929 Mixing and Dispersion in the Ocean
EESC GU4949 Introduction to Seismology
EESC GR6111 Modern analytical methods in geochemistry
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