Earth and Environmental Sciences

Departmental Offices:
556-7 Schermerhorn; 212-854-4525
106 Geoscience, Lamont-Doherty Earth Observatory; 845-365-8550
http://eesc.columbia.edu

Chair of Department:
Prof. Sidney Hemming, sidney@ldeo.columbia.edu

Director of Undergraduate Studies:
Prof. Meredith Nettles, Lamont-Doherty Earth Observatory; 845-365-8613;
557 Schermerhorn Extension; nettles@ldeo.columbia.edu

DEES Administrator for undergraduate courses: Anastasia Yankopoulous, aty2113@columbia.edu

Director of Academic Administration and Finance:
Sally Odland, 108 Geoscience, Lamont-Doherty Earth Observatory;
845-365-8633; odland@ldeo.columbia.edu

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

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

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

Programs of Study

Environmental Science Major

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

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

Earth Science Major

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

Concentrations

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

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

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

Departmental Honors

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

Professors

Nicholas Christie-Blick
Joel E. Cohen
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

<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 System</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH UN1101</td>
<td>Calculus I</td>
</tr>
</tbody>
</table>

Select one of the following three-course sequences:

- CHEM UN1403 General Chemistry I (Lecture)
- CHEM UN1404 and General Chemistry II (Lecture)
- PHYS UN1201 and General Physics I

CHEM UN1403 General Chemistry I (Lecture)

- PHYS UN1201 and General Physics I
- PHYS UN1202 and General Physics II

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:

<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 UN2300</td>
<td>Earth's Environmental Systems: The Life System</td>
</tr>
<tr>
<td>EESC UN3010</td>
<td>Field Geology</td>
</tr>
<tr>
<td>EESC BC3017</td>
<td>Environmental Data Analysis</td>
</tr>
</tbody>
</table>

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 and Solid Earth Dynamics

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

Geological Science

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>EESC GU4090</td>
<td>Introduction to Geochronology and Thermochronology</td>
</tr>
<tr>
<td>EESC GU4113</td>
<td>Introduction to Mineralogy</td>
</tr>
<tr>
<td>EESC GU4223</td>
<td>Sedimentary Geology</td>
</tr>
<tr>
<td>EESC GU4230</td>
<td>Crustal Deformation</td>
</tr>
<tr>
<td>EESC GU4701</td>
<td>Introduction to Igneous Petrology</td>
</tr>
<tr>
<td>EESC GU4887</td>
<td>Isotope Geology I</td>
</tr>
<tr>
<td>EESC GU4947</td>
<td>Plate Tectonics</td>
</tr>
</tbody>
</table>

It is strongly recommended that students focusing in geological science take the summer geology field course as their capstone experience.

Geochemistry

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN3015</td>
<td>The Earth’s Carbon Cycle</td>
</tr>
<tr>
<td>EESC BC3016</td>
<td>Environmental Measurements</td>
</tr>
<tr>
<td>EESC BC3200</td>
<td>Ecotoxicology</td>
</tr>
<tr>
<td>EESC GU4090</td>
<td>Introduction to Geochronology and Thermochronology</td>
</tr>
<tr>
<td>EESC GU4113</td>
<td>Introduction to Mineralogy</td>
</tr>
<tr>
<td>EESC GU4701</td>
<td>Introduction to Igneous Petrology</td>
</tr>
<tr>
<td>EESC GU4885</td>
<td>The Chemistry of Continental Waters</td>
</tr>
<tr>
<td>EESC GU4887</td>
<td>Isotope Geology I</td>
</tr>
<tr>
<td>EESC GU4926</td>
<td>Principles of Chemical Oceanography</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>EESC GU4008</td>
<td>Introduction to Atmospheric Science</td>
</tr>
<tr>
<td>EESC GU4920</td>
<td>Paleoclimatology</td>
</tr>
<tr>
<td>EESC GU4924</td>
<td>Introduction to Atmospheric Chemistry</td>
</tr>
<tr>
<td>EESC GU4925</td>
<td>Principles of Physical Oceanography</td>
</tr>
<tr>
<td>EESC GU4926</td>
<td>Principles of Chemical Oceanography</td>
</tr>
</tbody>
</table>
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-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: 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 Terrestrial Paleoclimate
- 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.

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**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 System
- 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 (Lecture) and General Chemistry II (Lecture) and General Physics I
- CHEM UN1404: General Chemistry I (Lecture) and General Chemistry II (Lecture) and General Physics I
- CHEM UN1405: General Chemistry I (Lecture) and General Chemistry II (Lecture) and General Physics I

It is recommended that students focusing in environmental geology also take EESC W4050 Remote Sensing.

**Capstone Experience**

- EESC BC3800: Senior Research Seminar
- EESC BC3801: Senior Research Seminar
- EESC UN3901: Environmental Science Senior Seminar

**Breadth and Related Fields Requirement**

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

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

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

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

**Depth Requirement**

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

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

- EESC UN3101: Geochemistry for a Habitable Planet
- 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: Environmental geophysics

It is recommended that students focusing in environmental geology also take EESC W4050 Remote Sensing.

**Environmental Geochemistry**

- EESC UN3015: The Earth's Carbon Cycle
- EESC GU4885: The Chemistry of Continental Waters
- EESC GU4888: Isotope Geology I
- EESC GU4924: Introduction to Atmospheric Chemistry
- EESC GU4926: Principles of Chemical Oceanography

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**Hydrology**
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</th>
<th>Description</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 System</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</th>
<th>Description</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</th>
<th>Description</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>
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<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 System</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)**

- **EEBE UN2001** Environmental Biology I: Elements to Organisms
- **EESC UN2100** Earth's Environmental Systems: The Climate System
- **EESC UN2200** Earth's Environmental Systems: The Solid Earth System
- **EEBE UN2002** Environmental Biology II: Organisms to the Biosphere

**Introductory Science (13 points)**

Select one of the following chemistry sequences:

- **CHEM UN1403** General Chemistry I (Lecture)
- **CHEM UN1404** General Chemistry II (Lecture)
- **CHEM UN1604** Intensive General Chemistry (Lecture)
- **CHEM UN2507** Intensive General Chemistry Laboratory

One term of statistics such as the following:

- **STAT UN1101** Introduction to Statistics
- **STAT UN1201** Calculus-Based Introduction to Statistics
- **BIOL BC2286** Statistics and Research Design
- **EEBE UN3005** Introduction to Statistics for Ecology and Evolutionary Biology
- **EEBE UN3087** Conservation Biology

**Advanced Environmental Biology (9 points)**

Three additional advanced EEBE 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 2019**

**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 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 1001</td>
<td>001/55552</td>
<td>M W 1:10pm - 2:25pm Room TBA</td>
<td>Paul Olsen</td>
<td>4</td>
<td>14/40</td>
</tr>
<tr>
<td>EESC 1001</td>
<td>001/55552</td>
<td>M 4:10pm - 7:10pm 603 Schermerhorn Hall</td>
<td>Paul Olsen</td>
<td>4</td>
<td>14/40</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.

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<tr>
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<th>Points</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC 1401</td>
<td>001/55553</td>
<td>M W 1:10pm - 2:25pm Room TBA</td>
<td>Paul Olsen</td>
<td>3</td>
<td>41/80</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 2019: EESC UN1600
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<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>001/55513</td>
<td>T Th 1:10pm - 2:25pm Room TBA</td>
<td>Peter Kelemen</td>
<td>3</td>
<td>100/110</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.

Spring 2019: EESC UN1200
<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 2200</td>
<td>001/75647</td>
<td>T Th 2:40pm - 3:55pm 603 Schermerhorn Hall</td>
<td>Steven Goldstein, Sidney Hemming</td>
<td>4.5</td>
<td>46/55</td>
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</table>

Fall 2019: EESC UN2200
<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 2200</td>
<td>001/55515</td>
<td>T Th 1:10pm - 2:25pm 603 Schermerhorn Hall</td>
<td>Maria Tolstoy, Jonathan Kingslake</td>
<td>4.5</td>
<td>32/50</td>
</tr>
</tbody>
</table>

EESC UN2230 Science for Sustainable Development. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Provides an introduction to natural science approaches essential to understanding central issues of sustainable development. Topics may include: climate, ecology/agriculture/biodiversity, energy, natural disasters, population dynamics, public health and water resources. Treatment includes background, methods and applications from selected settings throughout the world. Taught by specialists in a number of fields.

Fall 2019: EESC UN230
<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 2330</td>
<td>001/55505</td>
<td>M W 2:40pm - 3:55pm Room TBA</td>
<td>John Mutter, Ruth Defries</td>
<td>3</td>
<td>97/110</td>
</tr>
</tbody>
</table>

EESC UN3101 Geochemistry for a Habitable Planet. 3 points.
Prerequisites: Any 1000-level or 2000-level EESC course; MATH UN1101 Calculus I and CHEM UN103 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 2019: EESC UN3101
<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 3101</td>
<td>001/55506</td>
<td>T Th 11:40am - 12:55pm 417 Schermerhorn Hall</td>
<td>Terry Plank</td>
<td>3</td>
<td>32/35</td>
</tr>
</tbody>
</table>
EESC UN3400 Introduction to Computational Earth Science. 3 points.
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 seismic waves, groundwater flow, glacier growth, ocean currents and more. Simulations will be created by learning to program with a user-friendly language (Python). Student learning will be facilitated through a combination of lectures, in-class exercises, homework assignments and a final project on a student-selected modeling topic.

| Fall 2019: EESC UN3400 |
|---|---|---|---|---|
| Course Number | Section/Call Number | Times/Location | Instructor | Points |
| EESC 3400 | 001/55554 | T Th 2:40pm - 3:55pm 558 Ext Schermerhorn Hall | Kerry Key | 3 |

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

| Spring 2019: EESC UN3901 |
|---|---|---|---|---|
| Course Number | Section/Call Number | Times/Location | Instructor | Points |
| EESC 3901 | 001/00997 | Th 4:10pm - 6:00pm 805 Altschul Hall | Martin Stute | 3 |

| Fall 2019: EESC UN3901 |
|---|---|---|---|---|
| Course Number | Section/Call Number | Times/Location | Instructor | Points |
| EESC 3901 | 001/55556 | Th 4:10pm - 6:00pm Room TBA | Martin Stute, Jacqueline Austerman, Roisin Comnane | 3 |

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 2019: EESC GU4008 |
|---|---|---|---|---|
| Course Number | Section/Call Number | Times/Location | Instructor | Points |
| EESC 4008 | 001/55561 | Th 4:10pm - 6:40pm 214 Seeley W. Mudd Building | Lorenzo Polvani | 3 |

EESC GU4050 Global Assessment and Monitoring Using Remote Sensing. 3 points.
CC/GS: Partial Fulfillment of Science Requirement, Lab Required. 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.

| Fall 2019: EESC GU4050 |
|---|---|---|---|---|
| Course Number | Section/Call Number | Times/Location | Instructor | Points |
| EESC 4050 | 001/55526 | Th 5:40pm - 6:55pm 417 Schermerhorn Hall | Christopher Small | 3 |

EESC GU4113 Introduction to Mineralogy. 4 points.
Prerequisites: introductory geology or the equivalent, elementary college physics and chemistry, or the instructor’s 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 2019: EESC GU4113 |
|---|---|---|---|---|
| Course Number | Section/Call Number | Times/Location | Instructor | Points |
| EESC 4113 | 001/55517 | T Th 11:40am - 12:55pm 506 Schermerhorn Hall | Cornelia Class | 4 |

| EESC 4113 | 001/55517 | T 4:10pm - 5:00pm 506 Schermerhorn Hall | Cornelia Class | 4 |
EESC GU330 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 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 organimsal 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.

<table>
<thead>
<tr>
<th>Fall 2019: EESC GU4925</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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</thead>
<tbody>
<tr>
<td>EESC 4925</td>
<td>001/55508</td>
<td>T Th 2:40pm - 3:55pm</td>
<td>555 Schermerhorn Hall</td>
<td>Arnold, Ryan G Ahernathey</td>
<td>3</td>
<td>11/25</td>
</tr>
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</table>

**EESC GU4947 Plate Tectonics. 3 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.  
Development of a comprehensive understanding of deformation and evolution of Earth's surface through cross-disciplinary analysis of the plate-tectonic cycle. Topics include the thermal and chemical evolution of mid-ocean ridges, the deep-ocean basins, subduction zones, continental rifts and collisions, and hot spots; driving forces of plate motion and mantle convection; magmatism and volcanism; and faulting and earthquakes. Emphasizes integration of geophysical, geological and geochemical observations and processes, with a particular focus on observations from the ocean basins.

<table>
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<tr>
<th>Fall 2019: EESC GU4947</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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</thead>
<tbody>
<tr>
<td>EESC 4947</td>
<td>001/55533</td>
<td>T Th 1:10pm - 2:25pm</td>
<td>555 Schermerhorn Hall</td>
<td>James, Gaherty, Donna Shillington</td>
<td>3</td>
<td>4/20</td>
</tr>
</tbody>
</table>

**Spring 2019**

**EESC UN1003 Climate and Society: Case Studies. 3 points.**  
CC/GS: Partial Fulfillment of Science Requirement

Explores a series of environmental hazards (ozone depletion, El Nino, global warming) as examples of risk management. For each module, students will learn the scientific principles underlying each hazard and then will examine how social and economic policies were developed and implemented to mitigate the perceived risk.

<table>
<thead>
<tr>
<th>Spring 2019: EESC UN1003</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tbody>
<tr>
<td>EESC 1003</td>
<td>001/67888</td>
<td>T Th 10:10am - 11:25am</td>
<td>Room TBA</td>
<td>8 erbel H nisch</td>
<td>3</td>
<td>45/60</td>
</tr>
</tbody>
</table>

**EESC UN1010 Geological Excursion To Death Valley, CA. 2 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 7. 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: http://eesc.columbia.edu/courses/v1010/.

<table>
<thead>
<tr>
<th>Spring 2019: EESC UN1010</th>
<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 1010</td>
<td>001/71069</td>
<td>F 7:30pm - 9:00pm</td>
<td>558 Ext Schermerhorn Hall</td>
<td>Nicholas, Christie Blick</td>
<td>2</td>
<td>19/20</td>
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</table>

**EESC UN1101 Earth: Origin, Evolution, Processes, Future. 4 points.**  
CC/GS: Partial Fulfillment of Science Requirement

What is the nature of our planet and how did it form? This class explores Earth's internal structure, its dynamical character expressed in plate tectonics and earthquakes, and its climate system. It also explores what Earth's future may hold. Lecture and lab. Students who wish to take only the lectures should register for UN 1411.

<table>
<thead>
<tr>
<th>Spring 2019: EESC UN1101</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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</thead>
<tbody>
<tr>
<td>EESC 1101</td>
<td>001/13375</td>
<td>M W 10:10am - 11:25am</td>
<td>603 Schermerhorn Hall</td>
<td>Sedelia, Rodriguez</td>
<td>4</td>
<td>28/30</td>
</tr>
</tbody>
</table>

**EESC UN1411 Earth: Origin, Evolution, Processes, Future: Lectures. 3 points.**  
CC/GS: Partial Fulfillment of Science Requirement

What is the nature of our planet and how did it form? This class explores Earth's internal structure, its dynamical character expressed in plate tectonics and earthquakes, and its climate system. It also explores what Earth's future may hold.

<table>
<thead>
<tr>
<th>Spring 2019: EESC UN1411</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tbody>
<tr>
<td>EESC 1411</td>
<td>001/66443</td>
<td>M W 10:10am - 11:25am</td>
<td>603 Schermerhorn Hall</td>
<td>Sedelia, Rodriguez</td>
<td>3</td>
<td>29/35</td>
</tr>
</tbody>
</table>
EESC UN2100 Earth's Environmental Systems: The Climate System. 4.5 points.
CC/GS: Partial Fulfillment of Science Requirement, BC: Partial Fulfillment of General Education Requirement: Laboratory Science (SCI), BC: Fulfillment of General Education Requirement: Quantitative and Deductive Reasoning (QUA), Lab Required Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be reinstated.

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

Spring 2019: 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>001/68603</td>
<td>T Th 2:40pm - 3:55pm 703 Hamilton Hall</td>
<td>Arlene Fiore, Galen McKinley</td>
<td>4.5</td>
<td>35/50</td>
</tr>
<tr>
<td>EESC 2100</td>
<td>001/68603</td>
<td>T 4:10pm - 7:00pm 558 Ext Schermerhorn Hall</td>
<td>Arlene Fiore, Galen McKinley</td>
<td>4.5</td>
<td>35/50</td>
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</table>

Fall 2019: 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>
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</thead>
<tbody>
<tr>
<td>EESC 2100</td>
<td>001/55514</td>
<td>T Th 10:10am - 11:25am 603 Schermerhorn Hall</td>
<td>Jerry McManus, Adam Sobel</td>
<td>4.5</td>
<td>46/50</td>
</tr>
<tr>
<td>EESC 2100</td>
<td>001/55514</td>
<td>T 4:10pm - 7:00pm 555 Schermerhorn Hall</td>
<td>Jerry McManus, Adam Sobel</td>
<td>4.5</td>
<td>46/50</td>
</tr>
</tbody>
</table>

EESC UN2200 Earth's Environmental Systems: The Solid Earth 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 necessary.

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

Spring 2019: EESC UN2200

<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>
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<tbody>
<tr>
<td>EESC 2200</td>
<td>001/75647</td>
<td>T Th 2:40pm - 3:55pm 603 Schermerhorn Hall</td>
<td>Steven Goldstein, Sidney Hemming</td>
<td>4.5</td>
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</tbody>
</table>

Fall 2019: EESC UN2200

<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>
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<tbody>
<tr>
<td>EESC 2200</td>
<td>001/55515</td>
<td>T Th 1:10pm - 2:25pm 603 Schermerhorn Hall</td>
<td>Maria Tolstoy, Jonathan Kingslake</td>
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<tr>
<td>EESC 2200</td>
<td>001/55515</td>
<td>T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall</td>
<td>Maria Tolstoy, Jonathan Kingslake</td>
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<td>32/50</td>
</tr>
</tbody>
</table>

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.

Spring 2019: EESC UN2300

<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>
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<tbody>
<tr>
<td>EESC 2300</td>
<td>001/23152</td>
<td>M W 1:10pm - 2:25pm 833 Seeley W. Mudd Building</td>
<td>Paul Olsen, Matthew Palmer, John Burns</td>
<td>4.5</td>
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</tr>
</tbody>
</table>
EESC 2310 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.

<table>
<thead>
<tr>
<th>Spring 2019: EESC UN2310</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
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<tr>
<td>EESC 2310</td>
<td>001/71755</td>
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<td>W 4:10pm - 7:00pm 603 Schermerhorn Hall</td>
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<tr>
<td>EESC 2310</td>
<td>002/13996</td>
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<td>W 4:10pm - 7:00pm 555 Schermerhorn Hall</td>
<td>Paul Olsen, Matthew Palmer, John Burns</td>
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<tr>
<td>EESC 2310</td>
<td>003/11564</td>
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<td>W 4:10pm - 7:00pm 417 Schermerhorn Hall</td>
<td>Paul Olsen, Matthew Palmer, John Burns</td>
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<tr>
<td>EESC 2310</td>
<td>004/25354</td>
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<td>Th 4:10pm - 7:00pm 603 Schermerhorn Hall</td>
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<tr>
<td>EESC 2310</td>
<td>005/23797</td>
<td></td>
<td>Th 4:10pm - 7:00pm 555 Ext Schermerhorn Hall</td>
<td>Paul Olsen, Matthew Palmer, John Burns</td>
<td>0</td>
<td>2/24</td>
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</tbody>
</table>

EESC 3000 Tutorial Study in Earth and Environmental Sciences. 1-3 points.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: declared major in Earth and environmental sciences and the department’s permission.
Students with particular interest in one of the many components of the Earth and environmental sciences should approach a director of undergraduate studies during the registration period so that tutorial-level exposure to the subject can be arranged. Each point requires two hours each week of readings, discussion, and research work under the close supervision of a member of the Department of Earth and Environmental Sciences, Lamont-Doherty Earth Observatory, American Museum of Natural History, or Goddard Institute for Space Studies. In consultation with the supervisor, the student selects a topic for intensive study and the time and place of the tutorial discussion sessions. May be repeated for credit up to a maximum of 12 points, with a maximum of 6 points with each staff member.

<table>
<thead>
<tr>
<th>Spring 2019: EESC UN3000</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
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<td></td>
<td></td>
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EESC 3010 Field Geology. 2 points.
Fee: to be determined.
This course may be repeated for up to 9 points of credit if taken in different areas. Field study in various geologic settings. Plans for the courses are announced at the beginning of each term. Class size will depend on available space. Priority is given to majors in the Department of Earth and Environmental Sciences at Columbia College and School of General Studies. Barnard Environmental Science majors may enroll with the permission of the Barnard Environmental Science department chair. All others require the instructor’s permission.

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<thead>
<tr>
<th>Spring 2019: EESC UN3010</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
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<tr>
<td>EESC 3010</td>
<td>001/27293</td>
<td></td>
<td></td>
<td>Nicholas Christie-Blick</td>
<td>2</td>
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<tr>
<td>EESC 3010</td>
<td>002/83781</td>
<td></td>
<td>T 7:30pm - 9:30pm 603 Schermerhorn Hall</td>
<td>Steven Goldstein, Sidney Hemming</td>
<td>16/30</td>
<td>2/20</td>
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EESC 3201 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.

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<tr>
<th>Spring 2019: EESC UN3201</th>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tbody>
<tr>
<td>EESC 3201</td>
<td>001/62220</td>
<td></td>
<td>T 8:40am - 9:55am 603 Schermerhorn Hall</td>
<td>Meredith Nettles</td>
<td>3</td>
<td>9/40</td>
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</tbody>
</table>

EESC GU4076 Geologic Mapping. 3 points.
CC/GS: Partial Fulfillment of Science Requirement Limited enrollment.
Prerequisites: the instructor’s permission.
This course will cover the basics of geologic mapping such as: pacing, compass skills, reading topographic maps, three point problems, taking good field notes, and creating geologic maps. Class will include three Saturday field trips and a two-week mapping exercise. The Saturday field trips will explore the tectonic history of the greater New York City area, and will take place in April and May. The two-week trip will focus on detailed geologic mapping near Catskill, NY, and take place from May 23rd – June 6th.
EESC GU4210 Geophysical Fluid Dynamics. 3 points.
Required course for M.A./Ph.D. candidates focusing in physical oceanography and atmospheric sciences. Elective for undergraduate majors in the Department of Earth and Environmental Sciences.
Prerequisites: APMA E3101, APMA E3201 or equivalents and APPH E4200 or equivalent or the instructor’s permission.
Fundamental concepts in the dynamics of rotating stratified flows. Geostrophic and hydrostatic balances, potential vorticity, f and beta plane approximations, gravity and Rossby waves, geostrophic adjustment and quasigeostrophy, baroclinic and barotropic instabilities.

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

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

EESC GU4630 Air-sea interaction. 3 points.
Given in alternate years. Enrollment limited to 20. Priority based on seniority (graduate students, graduating seniors, etc.).
Prerequisites: solid background in mathematics, physics, and chemistry. Some background in fluid mechanics (as in EESC W4925/APPH E4200) or the instructor’s permission.
An overview of oceanic and atmospheric boundary layers including fluxes of momentum, heat, mass, (eg., moisture salt) and gases between the ocean and atmosphere; vertical distribution of energy sources and sinks at the interface including the importance of surface currents; forced upper ocean dynamics, the role of surface waves on the air-sea exchange processes and ocean mixed layer processes.

Spring 2019: EESC GU4210

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<tr>
<td>EESC 4210</td>
<td>001/74909</td>
<td>T 4:10pm - 6:40pm</td>
<td>Adam Sobel</td>
<td>3</td>
<td>6/35</td>
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<td>Jonathan Kingslake</td>
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<td>Th 1:10pm - 2:25pm</td>
<td>Jonathan Kingslake</td>
<td>3</td>
<td>7/20</td>
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Spring 2019: EESC GU4220

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<th>Instructor</th>
<th>Points</th>
<th>Enrollment</th>
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<tr>
<td>EESC 4220</td>
<td>001/72646</td>
<td>T Th 11:40am - 12:55pm</td>
<td>Jacqueline Austermann</td>
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Spring 2019: EESC GU4630

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<tr>
<td>EESC 4630</td>
<td>001/24725</td>
<td>T Th 2:40pm - 3:55pm</td>
<td>Christopher Zappa</td>
<td>3</td>
<td>7/20</td>
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</table>
EESC GU4888 Stable Isotope Geochemistry. 3 points.
Given in alternate years.

Prerequisites: introductory chemistry and earth science coursework.
Prerequisites: Introductory Chemistry and Earth Science coursework.
Given in alternate years. This class will be an introduction to the field of stable isotope geochemistry and its application to understanding current and past environmental processes. The utility of stable isotopes as tracers will be examined with respect to the disciplines of hydrology, oceanography, paleoclimatology, paleoceanography, landscape evolution, carbon cycle and nitrogen cycle dynamics. We will focus on the stable isotopes of hydrogen, carbon, oxygen, nitrogen in water, ice, carbonates and organic compounds and why they fractionate in the environment. The theoretical background for isotope fractionation will be discussed in class. Radiocarbon as a tracer and dating tool will also be reviewed. In addition, the mechanics of how mass spectrometers analyze different isotope ratios will be explored in class and during experiments in the laboratory. Additional key parts of the class will be a review of paper or laboratory report and student-lead reviews of published papers on relevant topics.

Spring 2019: EESC GU4888
Course Number Section/Call Times/Location Instructor Points Enrollment
EESC 4888 001/66946 T Th 8:40am - 9:55am 506 Schermerhorn Hall Braddock 3 10/30

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.

Spring 2019: EESC GU4923
Course Number Section/Call Times/Location Instructor Points Enrollment
EESC 4923 001/66811 T Th 4:10pm - 5:25pm 417 Schermerhorn Hall Andrew Juhl 3 8/30

EESC GU4924 Introduction to Atmospheric Chemistry. 3 points.
Prerequisites: Physics W1201, Chemistry W1403, Calculus III, or equivalent or the instructor’s 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 2019: EESC GU4924
Course Number Section/Call Times/Location Instructor Points Enrollment
EESC 4924 001/75846 T Th 11:40am - 12:55pm 417 Schermerhorn Hall Arlene Fiore 3 15/50

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

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

Spring 2019: EESC GU4926
Course Number Section/Call Times/Location Instructor Points Enrollment
EESC 4926 001/66426 T Th 1:10pm - 2:25pm 603 Schermerhorn Hall Robert Anderson 3 17/50

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

Spring 2019: EESC GU4930
Course Number Section/Call Times/Location Instructor Points Enrollment
EESC 4930 001/20680 T Th 1:10pm - 2:25pm 417 Schermerhorn Hall Arnold Gordon 3 6/40

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

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

Spring 2019: EESC GU4937
Course Number Section/Call Times/Location Instructor Points Enrollment
EESC 4937 001/69380 T Th 10:10am - 11:25am 417 Schermerhorn Hall Peter deMenocal, Maureen Raymo 3 13/50
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 2019: EESC GU4949
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 4949 001/11961 T Th 11:40am - 12:55pm 555 Schermerhorn Hall Felix Waldhauser 3 5/50

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 Climate Thermodynamics and Energy Transfer
EESC GU4085 Geodynamics
EESC GU4113 Introduction to Mineralogy
EESC GU4330 Introduction to Terrestrial Paleoclimate
EESC GU4223 Sedimentary Geology
EESC GU4300 The Earth's Deep Interior
EESC GU4630 Air-sea interaction
EESC GU4701 Introduction to Igneous Petrology
EESC GU4835 Wetlands and Climate Change
EESC GU4885 The Chemistry of Continental Waters
EESC GU4887 Isotope Geology I
EESC GU4888 Stable Isotope Geochemistry
EESC GU4920 Paleoceanography
EESC GU4926 Principles of Chemical Oceanography
EESC GU4937 Cenozoic Paleoceanography
EESC GU4929 Mixing and Dispersion in the Ocean
EESC GU4949 Introduction to Seismology

EESC GR6111 Modern analytical methods in geochemistry
EESC GR6701 Igneous and metamorphic processes during the creation and evolution of the tectonic plates
EESC GR6810 The Carbon Cycle
EESC GR6901 Research Computing for the Earth Sciences
EESC GR6909 Advanced Time Series Analysis
EESC GR6920 Dynamics of Climate
EESC GR6921 Atmospheric Dynamics
EESC GR6922 Atmospheric Radiation
EESC GR6928 Tropical Meteorology
EESC GR6949 Advanced Seismology
EESC GR6930 Ocean Dynamics
EESC GR9500 SEM-PLANT PHYSIOLOGY & EC