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.

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

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

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

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

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

Associate Professors
Jacqueline Austermann
Roisin Commane
Jonathan Kingslake

Assistant Professors
Folarin Kolawole
Yves Moussallam

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

Associsate Associate Professors
Anne Bécel

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

Guidelines for all Earth Science, Environmental Science, and Climate System Science Majors, Concentrators, and Special Concentrators

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

**Substitutions and Exceptions**

1. Higher-level courses may be used to satisfy supporting mathematics and science requirements for students with Advanced Placement preparation with the permission of the major adviser.

2. In addition to the courses listed for the depth, and breadth and related courses requirements, several graduate-level courses offered in the department as well as several advanced courses offered at Barnard may be substituted with the permission of the major adviser.

3. 1000-level courses in the Earth and Environmental Sciences Department can not be used toward meeting the requirements of any of the majors, concentrations, or special concentrations.

4. The following course is not suitable for undergraduates and cannot not be used toward meeting any of the requirements for the majors, concentrations, or special concentrations: EESC GU4930 EARTH’S OCEANS # ATMOSPHERE.

**Grading**

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

---

**Major in Earth Science**

Please read Guidelines for all Earth Science, Environmental Science, & Climate System Science Majors, Concentrators, and Special Concentrators above.

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

**Foundation Courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN2200</td>
<td>EARTH’S ENVIRONMENTAL SYSTEMS: THE SOIL EARTH</td>
</tr>
</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN2100</td>
<td>EARTH’S ENVIRO SYST: CLIM SYST</td>
</tr>
<tr>
<td>EESC UN2300</td>
<td>EARTH’S ENVIRO SYST: LIFE SYST</td>
</tr>
</tbody>
</table>

Students who wish to take both EESC UN2100 EARTH’S ENVIRO SYST: CLIM SYST and EESC UN2300 EARTH’S ENVIRO SYST: LIFE SYST can include one of these under breadth and related fields below.

**Supporting Mathematics and Science Courses**

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

<table>
<thead>
<tr>
<th>Course</th>
<th>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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM UN1403</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
</tr>
<tr>
<td>PHYS UN1201</td>
<td>GENERAL PHYSICS I</td>
</tr>
<tr>
<td>CHEM UN1403</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
</tr>
<tr>
<td>PHYS UN1201</td>
<td>GENERAL PHYSICS I</td>
</tr>
</tbody>
</table>

**Capstone Experience**

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC BC3800</td>
<td>ENVIR SCIENCE SENIOR SEMINAR and SENIOR SEMINAR</td>
</tr>
<tr>
<td>EESC BC3801</td>
<td>ENVIR SCIENCE SENIOR SEM II and SENIOR SEMINAR</td>
</tr>
</tbody>
</table>

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</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC BC3000</td>
<td>EARTH’S ENVIRO SYST: LIFE SYST</td>
</tr>
<tr>
<td>EESC UN2100</td>
<td>EARTH’S ENVIRONMENTAL SYSTEMS: THE SOIL EARTH</td>
</tr>
<tr>
<td>EESC UN3010</td>
<td>FIELD GEOLOGY</td>
</tr>
<tr>
<td>EESC BC3017</td>
<td>ENVIRONMENTAL DATA ANALYSIS</td>
</tr>
<tr>
<td>EESC GU4050</td>
<td>GLOBAL ASSESSMENT-REMOTE SENSING</td>
</tr>
<tr>
<td>EESC GU4600</td>
<td>EARTH RESOURCES # SUSTAIN DEV</td>
</tr>
<tr>
<td>EESC GU4917</td>
<td>THE EARTH/HUMAN INTERACTIONS</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:

<table>
<thead>
<tr>
<th>Course</th>
<th>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>

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</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC GU4090</td>
<td>INTRO TO GEOCHRONOLOGY</td>
</tr>
<tr>
<td>EESC GU4113</td>
<td>Mineralogy and Mineral Resources</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 AND CLIMATE</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</th>
<th>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>
</tbody>
</table>
The major in environmental science requires a minimum of 47 points, distributed as follows:

**Foundation Courses**

- EESC UN2100  EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
- EESC UN2200  EARTH'S ENVIRONMENTAL SYSTEMS: THE LIFE SYST
- EESC UN2300  EARTH'S ENVIRONMENTAL SYSTEMS: CLIMATE SYSTEM

**Supporting Mathematics and Science Courses**

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

- MATH UN1101  CALCULUS I
- MATH UN1201  CALCULUS II

Select one of the following three-course sequences:

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Course 1</th>
<th>Course 2</th>
<th>Course 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM UN1403-PHYS UN1201-MATH UN1201</td>
<td>GENERAL CHEMISTRY -LECTURES</td>
<td>GENERAL CHEMISTRY II-LECTURES</td>
<td>GENERAL PHYSICS I</td>
</tr>
<tr>
<td>CHEM UN1403-PHYS UN1201-MATH UN1202</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
<td>GENERAL PHYSICS I</td>
<td>GENERAL PHYSICS II</td>
</tr>
<tr>
<td>CHEM UN1403-PHYS UN1201-PHYS UN1202</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
<td>GENERAL PHYSICS I</td>
<td>GENERAL PHYSICS II</td>
</tr>
<tr>
<td>CHEM UN1403-PHYS UN1201-PHYS UN1202</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
<td>GENERAL PHYSICS I</td>
<td>GENERAL PHYSICS II</td>
</tr>
<tr>
<td>EEEB UN2001-PHYS UN1201-PHYS UN1202</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
<td>GENERAL PHYSICS I</td>
<td>GENERAL PHYSICS II</td>
</tr>
<tr>
<td>EEEB UN2001-PHYS UN1201-PHYS UN1202</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
<td>GENERAL PHYSICS I</td>
<td>GENERAL PHYSICS II</td>
</tr>
<tr>
<td>EEEB UN2001-PHYS UN1201-PHYS UN1202</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
<td>GENERAL PHYSICS I</td>
<td>GENERAL PHYSICS II</td>
</tr>
<tr>
<td>EEEB UN2001-PHYS UN1201-PHYS UN1202</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
<td>GENERAL PHYSICS I</td>
<td>GENERAL PHYSICS II</td>
</tr>
<tr>
<td>EEEB UN2001-PHYS UN1201-PHYS UN1202</td>
<td>GENERAL CHEMISTRY I-LECTURES</td>
<td>GENERAL PHYSICS I</td>
<td>GENERAL PHYSICS II</td>
</tr>
</tbody>
</table>

**Capstone Experience**

- EESC BC3800  ENVIR SCIENCE SENIOR SEMINAR
- EESC BC3801  ENVIR SCIENCE SENIOR SEM II
- EESC UN3901  SENIOR SEMINAR

**Breadth and Related Fields Requirement**

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

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

- EESC BC3017  ENVIRONMENTAL DATA ANALYSIS
- EESC GU4050  GLOBAL ASSEMT-REMOTE SENSING
- EESC GU4600  EARTH RESOURCES # SUSTAIN DEV
- EESC GU4917  THE EARTH/HUMAN INTERACTIONS
- EESC UN3010  FIELD GEOLOGY

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

**Depth Requirement**

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

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

- EESC UN3101  GEOCHEMISTRY FOR A HABITABLE PLANET

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

Hydrology
EESC GU4076 Geologic Mapping
EESC GU4835 Wetlands and Climate Change
EESC GU4885 CHEMISTRY OF CONTINENTL WATERS
EESC BC3025 HYDROLOGY
EAE E3221

Climate Change
EESC UN3015 The Earth’s Carbon Cycle
EESC GU4008 Introduction to Atmospheric Science
EESC GU4330 Introduction to Terrestrial Paleoclimate
EESC GU4480 Paleobiology and Earth System History
EESC GU4835 Wetlands and Climate Change
EESC GU4920 PALEOCEANOGRAPHY

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

Energy and Resources
EESC GU4076 Geologic Mapping
EESC GU4701 Introduction to Igneous Petrology
EAE E2002

Major in Climate System Science
Please read Guidelines for all Earth Science, Environmental Science, & Climate System Science Majors, Concentrators, and Special Concentrators above.

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

Foundational Courses
7.5 points minimum (2 courses):

Required:
EESC UN2100 EARTH’S ENVIRO SYST: CLIM SYST
And any one of:
EESC UN1009 GLOBAL WARMING FOR GLOBAL LEADERS
EESC UN1030 OCEANOGRAPHY
EESC UN1201 Environmental Risks and Disasters
EESC UN1600 EARTH RESOURCES # SUSTAIN DEV
or EESC GU4600 EARTH RESOURCES # SUSTAIN DEV
EESC UN2200 EARTH’S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH

Supporting Courses
12 points minimum (4 courses):

One semester of Calculus at the level of Calculus I or higher:
MATH UN1101 CALCULUS I
And any three courses:
PHYS UN1201 GENERAL PHYSICS I
PHYS UN1202 GENERAL PHYSICS II
CHEM UN1403 GENERAL CHEMISTRY I-LECTURES
CHEM UN1404 GENERAL CHEMISTRY II-LECTURES
EEBB UN2001 ENVIRONMENTAL BIOLOGY I
EESC UN2300 EARTH’S ENVIRO SYST: LIFE SYST

Climate System Core
15 points minimum (five courses):

Required: at least one Paleoclimate Course
EESC GU4235 SEA LEVEL CHANGE
EESC GU4330 Introduction to Terrestrial Paleoclimate
EESC GU4480 Paleobiology and Earth System History
EESC GU4920 PALEOCEANOGRAPHY
EESC GU4937 CENOZOIC PALEOCEANOGRAPHY

Required: at least one Modern Climate Course
EESC UN3031 CHEMISTRY OF CLIMATE
EESC UN3109 CLIMATE PHYSICS
EESC GU4008 Introduction to Atmospheric Science
EESC GU4020 HUMANS # THE CARBON CYCLE
EESC GU4040 CLIM THERMODYN/ENERGY TRANSFER
EESC GU4925 Principles of Physical Oceanography
EESC GU4930 EARTH’S OCEANS # ATMOSPHERE

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

Could include one: Supporting EESC Course
EESC UN3400 COMPUTATIONAL EARTH SCIENCE
EESC GU4210 GEOPHYSICAL FLUID DYNAMICS
EESC GU4223 SEDIMENTARY GEOLOGY
EESC GU4230 CRUSTAL DEFORMATION
EESC GU4887 ISOTOPE GEOLOGY I
EESC GU4888 Stable Isotope Geochemistry

Climate Solutions, Justice, Policy and Communication
6 points minimum (any two courses below):

Solutions Courses
EESC BC3045 RESPONDING TO CLIMATE CHANGE (Barnard College)
ARCH UN3120 CITY/LANDSCAPE, # ECOLOGY
EAE E2002
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 9 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 chosen from those listed under Depth Requirement for the earth science major above.

The third course selected from those listed under either Depth Requirement or Breadth and Related Fields Requirement for the earth science major above.

Concentration in Environmental Science
Please read Guidelines for all Earth Science, Environmental Science, & Climate System Science Majors, Concentrators, and Special Concentrators above.

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

**Foundation Courses**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN2100</td>
<td>EARTH'S ENVIRO SYST: CLIM SYST</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 ENVIRO SYST LIFE SYST</td>
</tr>
</tbody>
</table>

**Supporting Mathematics and Science Courses**
Two science or mathematics courses (6-7 points) selected from among those listed for the environmental science major above.

**Depth and Breadth and Related Fields Requirements**
A minimum of 6 points (two courses) is required as follows:

<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>

Approved Field Course focused on the Climate System
~6 weeks, must be proposed and then approved by DUS

Special Concentration in Environmental Science for Majors in Environmental Biology
Please read Guidelines for all Earth Science, Environmental Science, & Climate System Science Majors, Concentrators, and Special Concentrators above.

The Department of Earth and Environmental Sciences sponsors a special concentration which must be done in conjunction with the environmental biology major. Students should be aware that they must complete the environmental biology major in order to receive credit for the special concentration.
The special concentration in environmental science requires a minimum of 31.5 points, distributed as follows:

**Introductory Environmental Science (13.5 points)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EESC UN2100</td>
<td>EARTH’S ENVIRO SYST: CLIM SYST</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 ENVIRO SYST: LIFE SYST</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 Science, Environmental Science, & Climate System Science Majors, Concentrators, and Special Concentrators above.

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

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

**Introductory Environmental Biology and Environmental Science (17 points)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEEB UN2001</td>
<td>ENVIRONMENTAL BIOLOGY I</td>
</tr>
<tr>
<td>EESC UN2100</td>
<td>EARTH’S ENVIRO SYST: CLIM SYST</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</td>
</tr>
</tbody>
</table>

**Introductory Science (13 points)**

Select one of the following chemistry sequences:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</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</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT UN1101</td>
<td>INTRODUCTION TO STATISTICS</td>
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<tr>
<td>STAT UN1201</td>
<td>CALC-BASED INTRO TO STATISTICS</td>
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<tr>
<td>BIOL BC2286</td>
<td>Statistics and Research Design</td>
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</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.

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

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**Fall 2023**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<th>Enrollment</th>
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<tbody>
<tr>
<td>EESC UN1001</td>
<td>DINOSAURS AND HISTORY OF LIFE. 4.00 points.</td>
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</tbody>
</table>

CC/GS: Partial Fulfillment of Science Requirement

Given in alternate years.

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

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

**EEEB UN1030 OCEANOGRAPHY. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Enrollment limited to 160.

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

**Fall 2024: EESC UN1030**

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<td>EESC 1030</td>
<td>002/11443 T Th 12:50pm - 01:55pm Room TBA</td>
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<tr>
<td>EESC 1030</td>
<td>003/11444 T Th 01:10pm - 02:25pm Room TBA</td>
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</table>

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

**EEEB UN3005 INTRO-STAT-ECOLOGY & EVOL BIOL**

**EEEB UN3087 CONSERVATION BIOLOGY**
EESC UN1201 Environmental Risks and Disasters. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Priority given to first-years and sophomores.

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

Fall 2024: EESC UN1201
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 1201 001/11443 T Th 10:10am - 11:25am Room TBA Goran Ekstrom 3 0/60

EESC UN1401 Dinosaur # History of Life-Lec. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

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

EESC UN1600 Earth Resources # Sustain Dev. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement

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

Fall 2024: EESC UN1600
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 1600 001/11444 T Th 1:10pm - 2:25pm Room TBA Peter Kelemen 3.00 0/200

EESC UN2100 Earth’s Enviro Syst: Clim Syst. 4.50 points.
Prerequisites: high school algebra. Recommended preparation: high school chemistry and physics; and one semester of college science. Origin and development of the atmosphere and oceans, formation of winds, storms and ocean currents, reasons for changes through geologic time. Recent influence of human activity; the ozone hole, global warming, water pollution. Laboratory exploration of topics through demonstrations, experimentation, computer data analysis, and modeling. Students majoring in Earth and Environmental Sciences should plan to take EESC W2100 before their senior year to avoid conflicts with Senior Seminar

Spring 2024: EESC UN2100
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 2100 001/12424 T Th 10:10am - 11:25am 603 Schermerhorn Hall Mingfang Ting, Gisela Winckler 4.50 40/50
EESC 2100 001/12424 T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall Mingfang Ting, Gisela Winckler 4.50 40/50
EESC 2100 002/16962 T Th 1:10pm - 2:25pm 603 Schermerhorn Hall Michela Biasutti, Jennifer Middleton 4.50 15/25
EESC 2100 002/16962 W 4:10pm - 7:00pm 555 Ext Schermerhorn Hall Michela Biasutti, Jennifer Middleton 4.50 15/25

Fall 2024: EESC UN2100
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 2100 001/11445 T Th 10:10am - 11:25am 603 Schermerhorn Hall Jerry McManus, Suzana De Camargo 4.50 0/40
EESC 2100 001/11445 T 4:10pm - 7:00pm 555 Ext Schermerhorn Hall Jerry McManus, Suzana De Camargo 4.50 0/40
EESC UN2200 EARTH’S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH. 4.50 points.
CC/GS: Partial Fulfillment of Science Requirement
Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be necessary.

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

Spring 2024: EESC UN2200
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
EESC 2200  001/12441  T Th 2:40pm - 3:55pm  603 Schermerhorn Hall  Steven Goldstein, Sidney Hemming  4.50  51/55
EESC 2200  001/12441  T 4:10pm - 7:00pm  603 Schermerhorn Hall  Steven Goldstein, Sidney Hemming  4.50  51/55

Fall 2024: EESC UN2200
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
EESC 2200  001/11446  T Th 1:10pm - 2:25pm  603 Schermerhorn Hall  Yves Moussallam 4.50  0/40
EESC 2200  001/11446  Th 4:10pm - 7:00pm  603 Schermerhorn Hall  Yves Moussallam  4.50  0/40

EESC UN2330 SCIENCE FOR SUSTAINABLE DEVPT. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
The course provides students with the natural science basis to appreciate co-dependencies of natural and human systems, which are central to understanding sustainable development. After completing the course, students should be able to incorporate scientific approaches into their research or policy decisions and be able to use scientific methods of data analysis. The semester will highlight the climate system and solutions from both physical and ecological perspectives; water resources; food production and the cycling of nutrients; and the role of biodiversity in sustainable development. The course emphasizes key scientific concepts such as uncertainty, experimental versus observational approaches, prediction and predictability, the use of models and other essential methodological aspects.

Fall 2024: EESC UN2330
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
EESC 2330  001/11447  T Th 2:40pm - 3:55pm  Room TBA  John Mutter, Jenna Lawrence 3  0/120

EESC UN3101 Geochemistry for a Habitable Planet. 3 points.
Prerequisites: Any 1000-level or 2000-level EESC course; MATH UN1101 Calculus I and CHEM UN1043 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 2024: EESC UN3101
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
EESC 3101  001/11449  T Th 11:40am - 12:55pm  603 Schermerhorn Hall  Terry Plank 3  0/35

EESC UN3901 SENIOR SEMINAR. 3.00 points.
Prerequisites: EESC BC3800 or EESC BC3801 and a good grounding in basic sciences.
Guided, independent, in-depth research culminating in the senior thesis in the spring. Includes discussion about scientific presentations and posters, data analysis, library research methods and scientific writing. Students review work in progress and share results through oral reports. Weekly seminar to review work in progress and share results through oral and written reports

Spring 2024: EESC UN3901
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
EESC 3901  001/12520  Th 4:10pm - 6:00pm  202 Altschul Hall  Sidney Hemming, Jacqueline Austermann, Elizabeth Cook 3.00  21/50

Fall 2024: EESC UN3901
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
EESC 3901  001/11460  Th 4:10pm - 6:00pm  Room TBA 3.00  0/50

EESC GU4008 Introduction to Atmospheric Science. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: advanced calculus and general physics, or the instructor’s permission.
Basic physical processes controlling atmospheric structure: thermodynamics; radiation physics and radiative transfer; principles of atmospheric dynamics; cloud processes; applications to Earth’s atmospheric general circulation, climatic variations, and the atmospheres of the other planets.

Fall 2024: EESC GU4008
Course Number  Section/Call Number  Times/Location  Instructor  Points  Enrollment
EESC 4008  001/11461  T 4:10pm - 6:40pm  417 Schermerhorn Hall  Lorenzo Polvani 3  0/45
EESC GU4050 GLOBAL ASSMT-REMOTE SENSING. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement
Enrollment limited to 24. Priority given to graduate students in the natural sciences and engineering.

Prerequisites: Course Cap 20 students. Priority given to graduate students in the natural sciences and engineering. Advanced level undergraduates may be admitted with the instructor’s permission. Prerequisites: calculus, differential equations, introductory physics. An introduction to how the Earth and planets work. The focus is on physical processes that control plate tectonics and the evolution of planetary interiors and surfaces; analytical descriptions of these processes; weekly physical model demonstrations.

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

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

EESC GU4113 Mineralogy and Mineral Resources. 4.00 points.
Prerequisites: introductory geology or the equivalent, elementary college physics and chemistry, or the instructor’s permission.
Prerequisites: introductory geology or the equivalent, elementary college physics and chemistry, or the 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. In this course, we will approach mineralogy from the standpoint of earth and environmental sciences, the study of mineralogy however is of interest to many other sciences including Material Sciences, Planetology, Archeology, Biology, Chemistry and Physics with most of the 20 Nobel Prizes awarded for research involving crystals being in these last fields. The goal of this class is to (1) understand the physical and chemical properties of minerals, (2) learn techniques of mineral identification with an emphasis on optical mineralogy, (3) understand the relationship between minerals and the broader geological context.

EESC GU4330 Introduction to Terrestrial Paleoclimate. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

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

EESC GU4600 EARTH RESOURCES & SUSTAIN DEV. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement
Prerequisites: none; high school chemistry recommended.
Prerequisites: none; high school chemistry recommended. This course is open to graduate students, and juniors and seniors within DEES, Sus Dev, Engineering, Chemistry, Physics, and APAM - or with the instructors permission. Survey of the origin and extent of mineral resources, fossil fuels, and industrial materials, that are non renewable, finite resources, and the environmental consequences of their extraction and use, using the textbook Earth Resources and the Environment, by James Craig, David Vaughan and Brian Skinner. This course will provide an overview, but will include focus on topics of current societal relevance, including estimated reserves and extraction costs for fossil fuels, geological storage of CO2, sources and disposal methods for nuclear energy fuels, sources and future for luxury goods such as gold and diamonds, and special, rare materials used in consumer electronics (e.g., Coltan; mostly from Congo) and in newly emerging technologies such as superconducting magnets and rechargeable batteries (e.g. heavy rare earth elements, mostly from China). Guest lectures from economists, commodity traders and resource geologists will provide a real world; input

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

Prerequisites: introductory college-level biology and chemistry. An overview of the biology and ecology of the oceans with a focus on the interaction between marine organisms and the physics and chemistry of the oceans.
EESC GU4925 Principles of Physical Oceanography. 3 points.
CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: Recommended preparation: a solid background in mathematics, physics, and chemistry.
Physical properties of seawater, water masses and their distribution, sea-air interaction influence on the ocean structure, basic ocean circulation pattern, relation of diffusion and advection with respect to distribution of ocean properties, ocean tides and waves, turbulence, and introduction to ocean dynamics.

Fall 2024: EESC GU4925

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<td>EESC 4925</td>
<td>001/11471</td>
<td>T Th 8:40am - 9:55am</td>
<td>Andreas Thurnherr 417 Schermerhorn Hall</td>
<td>3</td>
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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.

Fall 2024: EESC GU4949

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<td>EESC 4949</td>
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<td>T Th 11:40am - 12:55pm 555 Ext Schermerhorn Hall</td>
<td>Felix Waldhauser</td>
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Spring 2024

EESC UN1009 GLOBAL WARMING FOR GLOBAL LEADERS. 3.00 points.
Global Warming will dominate civic discourse and inform economic, social, and governmental policies throughout the 21st century, in all walks of life. This course will cover the basics of climate science, anthropogenic global warming, proposed solutions and policy challenges facing society in response to our changing planet. This course will increase your confidence and ability to engage in public discourse on the subject of climate change, climate change solutions, and public policy concerning our collective future

Spring 2024: EESC UN1009

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<th>Course Number</th>
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<td>001/12410</td>
<td>T Th 11:40am - 12:55pm 603 Schermerhorn Hall Cin Alfred Lerner Hall</td>
<td>Maureen Raymo, Baerbel Hoenisch</td>
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<td>EESC 1009</td>
<td>AU/18951</td>
<td>T Th 11:40am - 12:55pm 555 Ext Schermerhorn Hall</td>
<td>Maureen Raymo, Baerbel Hoenisch</td>
<td>3.00 9/11</td>
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</table>

EESC UN1010 GEOLO EXCUR TO DEATH VALLEY, CA. 2.00 points.
Enrollment limited to 20.
The trip is restricted to first-years and sophomores from Columbia College/General Studies, Barnard College, and the School of Engineering and Applied Science. Early application is advised, and no later than November 12. A spring-break excursion focused on the geology of Death Valley and adjacent areas of the eastern California desert. Discussion sessions ahead of the trip provide necessary background. Details at:
https://eesc.columbia.edu/content/eesc-un1010

Spring 2024: EESC UN1010

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<td>F 5:30pm - 7:00pm 555 Ext Schermerhorn Hall</td>
<td>Folarin Kolawole</td>
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EESC UN2100 EARTH’S ENVIRO SYST: CLIM SYST. 4.50 points.
Prerequisites: high school algebra. Recommended preparation: high school chemistry and physics; and one semester of college science. Origin and development of the atmosphere and oceans, formation of winds, storms and ocean currents, reasons for changes through geologic time. Recent influence of human activity: the ozone hole, global warming, water pollution. Laboratory exploration of topics through demonstrations, experimentation, computer data analysis, and modeling. Students majoring in Earth and Environmental Sciences should plan to take EESC W2100 before their senior year to avoid conflicts with Senior Seminar

Spring 2024: EESC UN2100

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<th>Course Number</th>
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<tr>
<td>EESC 2100</td>
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<tr>
<td>EESC 2100</td>
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<td>T Th 1:10pm - 2:25pm 603 Schermerhorn Hall</td>
<td>Michela Biasutti, Jennifer Middleton</td>
<td>4.50 15/25</td>
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<tr>
<td>EESC 2100</td>
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<td>4.50 15/25</td>
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Fall 2024: EESC UN2100

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<td>EESC 2100</td>
<td>001/11445</td>
<td>T Th 10:10am - 11:25am 603 Schermerhorn Hall</td>
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<tr>
<td>EESC 2100</td>
<td>001/11445</td>
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<td>Jerry McManus, Suzana De Camargo</td>
<td>4.50 0/40</td>
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</table>
EESC UN2200 EARTH’S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH. 4.50 points.

CC/GS: Partial Fulfillment of Science Requirement

Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be necessary.

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

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

Spring 2024: EESC UN2200

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<th>Course Number</th>
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<td>EESC 2200</td>
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<td>Steven Goldstein, Sidney Hemming</td>
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<td>603 Schermerhorn Hall</td>
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<td>603 Schermerhorn Hall</td>
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Fall 2024: EESC UN2200

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<tr>
<td>EESC 2200</td>
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<td>T Th 1:10pm - 2:25pm</td>
<td>Yves Moussallam</td>
<td>4.50</td>
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<td>EESC 2200</td>
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EESC UN3010 FIELD GEOLOGY. 3.00 points.

Fee: to be determined.

The centerpiece of this course is a geological field trip during Spring Break in Barbados. The class will meet weekly before the trip to prepare for it and after the trip to synthesize what was learned and to create a field guide. Subjects to be covered: plate tectonics, convergent plate margins and accretionary prisms, local Barbados geology; ice ages, Milankovitch cycles, sea level; introduction to coral reefs and fossil coral reef geology; Barbados terrestrial ecology; limestone caves, hydrology; dating methods; overview of Barbados history, economy, culture. In order to observe the modern-day coral reef (the modern day live analog to the fossil coral reefs we will see) the class will go snorkeling. In order to observe the effects of cave formation and water flow in limestone terrains the class will participate in an extensive visit to a cave. The class will also participate in an exercise in geological mapping of a series of coral reef terraces. Priority: Priority is given to junior and senior majors and concentrators in Earth Science or Environmental Science at Columbia College and the School of General Studies, and Barnard College Environmental Science majors and minors. Others (non-DEES majors and non-Barnard Environmental Science students) may also be allowed to enroll if space permits. All students need permission of the instructor. Students who sign up will be put on a waitlist and will be considered after contacting the instructor.

Spring 2024: EESC UN3010

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<th>Course Number</th>
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<tr>
<td>EESC 3010</td>
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<td>T 7:30pm - 9:20pm</td>
<td>Steven Goldstein, Sidney Hemming</td>
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EESC UN3109 CLIMATE PHYSICS. 3.00 points.

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

Spring 2024: EESC UN3109

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**EESC UN3201 SOLID EARTH DYNAMICS. 3.00 points.**
Prerequisites: any 1000-level or 2000-level EESC course; MATH UN1101 Calculus I and PHYS UN1201 General Physics I or their equivalents. Concurrent enrollment in PHYS UN1201 is acceptable with the instructor’s permission.
Prerequisites: any 1000-level or 2000-level EESC course; MATH UN1101 Calculus I and PHYS UN1201 General Physics I or their equivalents. Concurrent enrollment in PHYS UN1201 is acceptable with the instructors permission. Properties and processes affecting the evolution and behavior of the solid Earth. This course will focus on the geophysical processes that build mountains and ocean basins, drive plate tectonics, and otherwise lead to a dynamic planet. Topics include heat flow and mantle circulation, earthquakes and seismic waves, gravity, Earth’s magnetic field, and flow of glaciers and ice sheets.

**EESC UN3901 SENIOR SEMINAR. 3.00 points.**
Prerequisites: EESC BC3800 or EESC BC3801 and a good grounding in basic sciences.
Guided, independent, in-depth research culminating in the senior thesis in the spring. Includes discussion about scientific presentations and posters, data analysis, library research methods and scientific writing. Students review work in progress and share results through oral reports. Weekly seminar to review work in progress and share results through oral and written reports.

**EESC GU4090 INTRO TO GEOCHRONOLGY. 3.00 points.**
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.
Prerequisites: one term of college-level calculus, and solid Earth system science or its equivalent.
An overview of approaches to estimating ages of sedimentary sequences and events in Earth history—to be co listed at Stony Brook and Rutgers. Intended for students with good backgrounds in the physical sciences, who want to use geochronological techniques in their studies. Because of the hands-on nature of geochronology and thermochronology, we are going to run the course as a series of 5 workshops held on Saturdays (possibly a Sunday depending on scheduling).

**EESC GU4210 GEOPHYSICAL FLUID DYNAMICS. 3.00 points.**
Required course for M.A./Ph.D. candidates focusing in physical oceanography and atmospheric sciences. Elective for undergraduate majors in the Department of Earth and Environmental Sciences.
Prerequisites: APMA E3101, APMA E3201 or equivalents and APPH E4200 or equivalent or the instructor’s permission.
Prerequisites: APMA E3101, APMA E3201 or equivalents and APPH E4200 or equivalent or the instructors permission. Fundamental concepts in the dynamics of rotating stratified flows. Geostrophic and hydrostatic balances, potential vorticity, f and beta plane approximations, gravity and Rossby waves, geostrophic adjustment and quasigeostrophy, baroclinic and barotropic instabilities.

**EESC GU4300 THE EARTH’S DEEP INTERIOR. 3.00 points.**
Prerequisites: Vector calculus, differential equations, one year of college physics (mechanics, electromagnetism, waves)
An overview of the geophysical study of the Earth, drawing upon geodesy, gravity, seismology, thermal studies, geomagnetism, materials science, and some geochemistry. Covers the principal techniques by which discoveries have been made, and are made, in deep Earth structure. Describes fundamental properties and features of the crust, mantle, and core.

### Spring 2024: EESC GU4210

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### Fall 2024: EESC UN3901

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<td>EESC 4300</td>
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### Fall 2024: EESC UN3901

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<td>Sidney Hemming, Jacqueline Austermann, Elizabeth Cook</td>
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### EESC GU4560 THE ECOLOGY OF TREELINE IN A CHANGING CLIMATE. 3.00 points.

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

**Spring 2024: EESC GU4560**

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<td>Kevin Griffin</td>
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### EESC GU4885 CHEMISTRY OF CONTINENTAL WATERS. 3.00 points.

Given in alternate years.

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

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

**Spring 2024: EESC GU4885**

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<td>Robert Anderson</td>
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### EESC GU4920 PALEOCEANOGRAPHY. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Given in alternate years.

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

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

**Spring 2024: EESC GU4920**

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### EESC GU4924 INTRO TO ATMOSPHERIC CHEMISTRY. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: Physics UN1201, Chem UN1403, & Math UN1201 (Calc III), or their equivalents. Recommended: EESC UN2100 or EESC GU4008.

Prerequisites: Physics W1201, Chemistry W1403, Calculus III, or equivalent or the instructors permission. EESC W2100 preferred. Physical and chemical processes determining atmospheric composition and the implications for climate and regional air pollution. Atmospheric evolution and human influence; basics of greenhouse effect, photolysis, reaction kinetics; atmospheric transport of trace species; stratospheric ozone chemistry; tropospheric hydrocarbon chemistry; oxidizing power, nitrogen, oxygen, sulfur, carbon, mercury cycles; chemistry-climate-biosphere interactions; aerosols, smog, acid rain.

**Spring 2024: EESC GU4924**

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EESC GU4947 PLATE TECTONICS AND CLIMATE. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

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

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

Spring 2024: EESC GU4947
Course Number: EESC 4947
Section/Call Number: 001/12564
Times/Location: T Th 2:40pm - 3:55pm
Instructor: W Buck
Points: 3.00
Enrollment: 8/40

EESC GR9910 SEM IN ATMOSPHERIC SCIENCE. 1.00-3.00 points.
May be repeated for up to 10 points of credit.

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

Of Related Interest
Environmental Science (Barnard)
EESC BC1001 Environmental Science I
EESC BC1011 Environmental Science I Lab
EESC BC3014 Field Methods in Environmental Science
EESC BC3016 ENVIRONMENTAL MEASUREMENTS
EESC BC3017 ENVIRONMENTAL DATA ANALYSIS
EESC BC3025 HYDROLOGY
EESC BC3033 Waste Management
EESC BC3050 BIG DATA WITH PYTHON
EESC BC3200 Ecotoxicology
EESC BC3300 WORKSHOP SUSTAINABLE DEVELOPMENT

Physics
PHYS UN1018 WEAPONS OF MASS DESTRUCTION

Generally Alternate Year Courses
EESC UN1001 DINOSAURS AND HISTORY OF LIFE
EESC UN1201 Environmental Risks and Disasters
EESC UN1401 DINOSAUR & HISTORY OF LIFE-LEC
EESC UN3015 The Earth’s Carbon Cycle
EESC GU4009 CHEMICAL GEOLOGY
EESC GU4040 CLIM THERMODYN/ENERGY TRANSFER
EESC GU4085 GEODYNAMICS
EESC GU4085 CHEMISTRY OF CONTINENTAL WATERS
EESC GU4086 ISOTOPES GEOLOGY I
EESC GU4087 Stable Isotope Geochemistry
EESC GU4088 PALEOCEANOGRAPHY
EESC GU4089 INTRO TO CHEMICAL OCEANOGRAPHY
EESC GU4091 CENOZOIC PALEOCEANOGRAPHY
EESC GU4092 Mixing and Dispersion in the Ocean
EESC GU4093 Introduction to Seismology
EESC GR6111 Modern analytical methods in geochemistry
EESC GR6810 The Carbon Cycle
EESC GR6901 Research Computing for the Earth Sciences
EESC GR6909 Advanced Time Series Analysis
EESC GR6920 DYNAMICS OF CLIMATE
EESC GR6921 ATMOSPHERIC DYNAMICS
EESC GR6922 ATMOSPHERIC RADIATION
EESC GR6928 TROPICAL METEOROLOGY
EESC GR6949 ADVANCED SEISMOLOGY I
EESC GR6950 Ocean Dynamics
EESC GR9500 SEM-PLANT PHYSIOLOGY & EC