The overall goal is to establish the fundamental sciences at the core of the climate system, and to inspire solution-oriented analytical thinking and expertise. The flexible course structure combines geology, physics, biology, chemistry, and math with a core in climate system science and climate solution, justice, policy and communication courses. Sample tracks through the major in sea level change, decarbonization and modern climate link to the mission and applied centers of Columbia’s Climate School. We believe that any admitted student has the potential to succeed in climate science.

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

Concentrations
The program for concentrators serves students who want more exposure to Earth and environmental science than is provided by introductory-level courses. The program aims to provide concentrators with experience in data analysis and a thorough introduction to the Earth’s systems.
The concentrations in environmental science and in Earth science are designed to give students an understanding of how the Earth works and an introduction to the methods used to investigate Earth processes, including their capabilities and limitations. Concentrators often join the social professions (e.g., business, law, medicine, etc.) and take with them a strong scientific background. They take the same introductory courses as the majors, but fewer basic science and upper-level courses are required.

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

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

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

**Associate Professors**
Jacqueline Austrermann  
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  

**Adjunct 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 can not be used toward meeting any of the requirements for the majors, concentrations, or special concentrations: EESC GU4930 EARTH’S OCEANS # ATMOSPHERE.

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

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

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

Foundation Courses
EESC UN2100 EARTH’S ENVIRO SYST: CLIM SYST
EESC UN2200 EARTH’S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH

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

Supporting Mathematics and Science Courses
One semester of Calculus at the level of Calculus I or higher (3 credits)

MATH UN1101 CALCULUS I
Select one of the following three-course sequences:
CHEM UN1403 GENERAL CHEMISTRY I-LECTURES and GENERAL CHEMISTRY II-LECTURES and GENERAL PHYSICS I
- CHEM UN1404 - PHYS UN1201
- PHYS UN1201

CHEM UN1403 GENERAL CHEMISTRY I-LECTURES and GENERAL PHYSICS I and GENERAL PHYSICS II
- PHYS UN1202

Capstone Experience
Select one of the following:
EESC BC3800 ENVR SCIENCE SENIOR SEMINAR
- EESC UN3901 and SENIOR SEMINAR
EESC BC3801 ENVR SCIENCE SENIOR SEM II and SENIOR SEMINAR

A six to eight week summer geology field course

Breadth and Related Fields Requirement
A minimum of 6 points (two courses) chosen with the major adviser are required.

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

EESC UN2100 EARTH’S ENVIRO SYST: CLIM SYST
EESC UN2300 EARTH’S ENVIRO SYST: LIFE SYST
EESC UN3010 FIELD GEOLOGY
EESC BC3017 ENVIRONMENTAL DATA ANALYSIS
EESC GU4050 GLOBAL ASSMT-REMOTE SENSING
EESC GU4600 EARTH RESOURCES # SUSTAIN DEV
EESC GU4917 THE EARTH/HUMAN INTERACTIONS
EABE E2002 ALTERNATIVE ENERGY RESOURCES

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

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

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

EESC UN3101 Geochemistry for a Habitable Planet
or EESC UN3201 SOLID EARTH DYNAMICS

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

Geological Science
EESC GU4090 INTRO TO GEOCHRONOLGY
EESC GU4113 INTRODUCTION TO MINERALOGY I
EESC GU4223 SEDIMENTARY GEOLOGY
EESC GU4230 CRUSTAL DEFORMATION
EESC GU4701 Introduction to Igneous Petrology
EESC GU4887 ISOPO GEOLGY I
EESC GU4947 PLATE TECTONICS

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

Geochemistry
EESC UN3015 The Earth’s Carbon Cycle
EESC BC3016 ENVIRONMENTAL MEASURMENTS
EESC BC3200 Ecotoxicology
EESC GU4090 INTRO TO GEOCHRONOLGY
EESC GU4113 INTRODUCTION TO MINERALOGY I
EESC GU4701 Introduction to Igneous Petrology
EESC GU4885 CHEMISTRY OF CONTINENTL WATERS
EESC GU4887 ISOPO GEOLGY I
EESC GU4926 INTRO TO CHEMICAL OCEANOGRAPHY
Earth and Environmental Sciences

It is recommended that students focusing in geochemistry take CHEM UN1403-CHEM UN1404 General Chemistry I and II, and PHYS UN1201 General Physics I as their supporting science sequence.

Atmosphere and Ocean Science

EESC GU4008 Introduction to Atmospheric Science
EESC GU4920 PALEOCEANOGRAPHY
EESC GU4924 INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4925 Principles of Physical Oceanography
EESC GU4926 INTRO TO CHEMICAL OCEANOGRAPHY

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

Solid Earth Geophysics

EESC GU4230 CRUSTAL DEFORMATION
EESC GU4300 THE EARTH'S DEEP INTERIOR
EESC GU4920 PALEOCEANOGRAPHY
EESC GU4924 INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4925 Principles of Physical Oceanography
EESC GU4949 Introduction to Seismology

It is recommended that students focusing in solid Earth geophysics take PHYS UN1201-PHYS UN1202 General Physics I and II, and CHEM UN1403 General Chemistry I as their supporting science sequence and also take MATH UN1201 Calculus II.

Climate

EESC UN3015 The Earth’s Carbon Cycle
EESC BC3025 HYDROLOGY
EESC GU4008 Introduction to Atmospheric Science
EESC GU4330 Introduction to Terrestrial Paleoclimate
EESC GU4835 Wetlands and Climate Change
EESC GU4920 PALEOCEANOGRAPHY
EESC GU4924 INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4925 Principles of Physical Oceanography
EESC GU4937 CENOZOIC PALEOCEANOGRAPHY

Paleontology

EESC GU4223 SEDIMENTARY GEOLOGY
EESC GU4550 Plant Ecophysiology
EESC GU4920 PALEOCEANOGRAPHY
EESC GU4924 INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4937 CENOZOIC PALEOCEANOGRAPHY

It is recommended that students focusing in paleontology take EESC UN2300 Earth’s Environmental Systems: The Life System, as one of their foundation courses.

Supporting Mathematics and Science Courses

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

MATH UN1101 CALCULUS I

Select one of the following three-course sequences:

CHEM UN1403 GENERAL CHEMISTRY I-LECTURES
- CHEM UN1404 and GENERAL CHEMISTRY II-LECTURES
- PHYS UN1201 and GENERAL PHYSICS I

CHEM UN1403 GENERAL CHEMISTRY I-LECTURES
- PHYS UN1201 and GENERAL PHYSICS I
- PHYS UN1202 and GENERAL PHYSICS II

CHEM UN1403 GENERAL CHEMISTRY I-LECTURES
- EEEB UN2001 and ENVIRONMENTAL BIOLOGY I
- PHYS UN1201 and GENERAL PHYSICS I

Capstone Experience

EESC BC3800 ENVIR SCIENCE SENIOR SEMINAR
or 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 ASMT-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
or EESC UN3201 SOLID EARTH DYNAMICS

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

Environmental Geology

EESC GU4076 Geologic Mapping
EESC GU4480 Paleobiology and Earth System History
EAEE E3221

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

Environmental Geochemistry

Major in Environmental Science

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

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

Foundation Courses

EESC UN2100 EARTH'S ENVIRO SYST: CLIM SYST
EESC UN2200 EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300 EARTH'S ENVIRO SYST: LIFE SYST
Earth and Environmental Sciences

EESC UN3015  The Earth’s Carbon Cycle
EESC GU4885  CHEMISTRY OF CONTINENTL WATERS
EESC GU4887  ISOTOPE GEOLOGY I
EESC GU4924  INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4888  Stable Isotope Geochemistry
EESC GU4926  INTRO TO CHEMICAL OCEANOGRAPHY

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

Climate Change
EESC UN3015  The Earth’s Carbon Cycle
EESC GU4008  Introduction to Atmospheric Science
EESC GU4330  Introduction to Terrestrial Paleoclimate
EESC GU4480  Paleobiology and Earth System History
EESC GU4835  Wetlands and Climate Change
EESC GU4920  PALEOCEANOGRAPHY
It is recommended that students focusing in environmental geology also take EESC GU4050 Remote Sensing.

Energy and Resources
EESC GU4076  Geologic Mapping
EESC GU4701  Introduction to Igneous Petrology
EAEE E2002  ALTERNATIVE ENERGY RESOURCES

Major in Climate System Science

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

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

Foundational Courses
7.5 points minimum (2 courses):
Required:
EESC UN2100  EARTH’S ENVIRO SYST: CLIM SYST
And any one of:
EESC UN1009  GLOBAL WARMING FOR GLOBAL LEADERS
EESC UN1030  OCEANOGRAPHY
EESC UN1201  Environmental Risks and Disasters
EESC UN1600  EARTH RESOURCES # SUSTAIN DEV
or EESC GU4600  EARTH RESOURCES # SUSTAIN DEV
EESC UN2200  EARTH’S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN2300  EARTH’S ENVIRO SYST: LIFE SYST
EESC UN2330  SCIENCE FOR SUSTAINABLE DEVPT

Supporting Courses
12 points minimum (4 courses):
One semester of Calculus at the level of Calculus I or higher:
MATH UN1101  CALCULUS I
And any three courses:

Climate System Core
15 points minimum (five courses):
Required: at least one Paleoclimate Course
EESC GU4235  SEA LEVEL CHANGE
EESC GU4330  Introduction to Terrestrial Paleoclimate
EESC GU4480  Paleobiology and Earth System History
EESC GU4920  PALEOCEANOGRAPHY
EESC GU4937  CENOZOIC PALEOCEANOGRAPHY
Required: at least one Modern Climate Course
EESC UN3109  CLIMATE PHYSICS
EESC GU4008  Introduction to Atmospheric Science
EESC GU4020  HUMANS # THE CARBON CYCLE
EESC GU4040  CLIM THERMODYN/ENERGY TRANSFER
EESC GU4925  Principles of Physical Oceanography
EESC GU4930  EARTH’S OCEANS # ATMOSPHERE
Could include: Other Climate System Course
EESC BC3109 Hydrology
EESC UN3101  Geochemistry for a Habitable Planet
EESC UN3201  SOLID EARTH DYNAMICS
EESC GU4220  GLACIOLOGY
EESC GU4835  Wetlands and Climate Change
EESC GU4885  CHEMISTRY OF CONTINENTL WATERS
EESC GU4923  Biological Oceanography
EESC GU4924  INTRO TO ATMOSPHERIC CHEMISTRY
EESC GU4926  INTRO TO CHEMICAL OCEANOGRAPHY
Could include one: Supporting EESC Course
EESC UN3400  COMPUTATIONAL EARTH SCIENCE
EESC GU4210  GEOPHYSICAL FLUID DYNAMICS
EESC GU4223  SEDIMENTARY GEOLOGY
EESC GU4230  CRUSTAL DEFORMATION
EESC GU4887  ISOTOPE GEOLOGY I
EESC GU4888  Stable Isotope Geochemistry

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

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

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

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

**Foundation Courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>EESC UN2100</td>
<td>EARTH’S ENVIRO SYST: CLIM SYST</td>
</tr>
<tr>
<td>or EESC UN2300</td>
<td>EARTH’S ENVIRO SYST: LIFE SYST</td>
</tr>
<tr>
<td>EESC UN2200</td>
<td>EARTH’S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH</td>
</tr>
</tbody>
</table>

**Supporting Mathematics and Science Courses**

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

**Depth and Breadth and Related Fields Requirements**

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

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

One additional course chosen from those listed under Depth Requirement for the earth science major above.

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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</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>

**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>
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<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>

One additional course selected from those listed under either Depth Requirement or Breadth and Related Fields Requirement for the environmental science major above.

Special Concentration in Environmental Science for Majors in Environmental Biology

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

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

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

**Introductory Environmental Science (13.5 points)**

<table>
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<tbody>
<tr>
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<tr>
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<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)
EEEB UN2001 ENVIRONMENTAL BIOLOGY I
EESC UN2100 EARTH’S ENVIRO SYST: CLIM SYST
EESC UN2200 EARTH’S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EEEB UN2002 ENVIRONMENTAL BIOLOGY II

Introductory Science (13 points)
Select one of the following chemistry sequences:
CHEM UN1403 GENERAL CHEMISTRY I-LECTURES
- CHEM UN1404 GENERAL CHEMISTRY II-LECTURES
CHEM UN1604 2ND TERM GEN CHEM (INTENSIVE)
- CHEM UN2507 and Intensive General Chemistry Laboratory

One term of statistics such as the following:
STAT UN1101 INTRODUCTION TO STATISTICS
STAT UN1201 CALC-BASED INTRO TO STATISTICS
BIOL BC2286 Statistics and Research Design
EEEB UN3005 INTRO-STATECOLOGY # EVOL BIOL
EEEB UN3087 CONSERVATION BIOLOGY

Advanced Environmental Biology (9 points)
Three additional advanced EEEB courses (3000-level and above), each chosen from a different curricular area (evolution/genetics, ecology/behavior/conservation, anatomy/physiology/diversity, biology laboratory courses).

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

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

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

Fall 2023
EESC UN1001 DINOSAURS AND HISTORY OF LIFE. 4.00 points.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

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

EESC UN1030 OCEANOGRAPHY. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement
Enrollment limited to 160.

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

Fall 2023: EESC UN1030
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 1030 001/13126 T Th 11:40am - 12:55pm 501 Northwest Corner Baerbel Hoenisch 3.00 149/160
EESC UN1201 Environmental Risks and Disasters. 3 points.
CC/GS: Partial Fulfillment of Science Requirement
Priority given to first-years and sophomores.

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

Fall 2023: EESC UN1201
<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 1201</td>
<td>001/13127</td>
<td>T Th 10:10am - 11:25am</td>
<td>Goran Ekstrom</td>
<td>3</td>
<td>42/60</td>
</tr>
</tbody>
</table>

EESC UN1401 DINOSAUR # HISTORY OF LIFE-LEC. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement
Given in alternate years.

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

Fall 2023: EESC UN1401
<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 1401</td>
<td>001/13128</td>
<td>M W 1:10pm - 2:25pm</td>
<td>Paul Olsen</td>
<td>3.00</td>
<td>60/100</td>
</tr>
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</table>

EESC UN1600 EARTH RESOURCES # SUSTAIN DEV. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement

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

Fall 2023: EESC UN1600
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<tr>
<td>EESC 1600</td>
<td>001/13129</td>
<td>T Th 1:10pm - 2:25pm</td>
<td>Peter Kelemen</td>
<td>3.00</td>
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EESC UN2100 EARTH’S ENVIRONMENTAL SYSTEMS. 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 2023: EESC UN2100
<table>
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<th>Course Number</th>
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<tr>
<td>EESC 2100</td>
<td>001/11149</td>
<td>T Th 10:10am - 11:25am</td>
<td>Mingfang Ting, Gisela Winckler</td>
<td>4.50</td>
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<tr>
<td>EESC 2100</td>
<td>001/11149</td>
<td>T 4:10pm - 7:00pm</td>
<td>Mingfang Ting, Gisela Winckler</td>
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Fall 2023: EESC UN2100
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<tr>
<td>EESC 2100</td>
<td>001/13062</td>
<td>T Th 10:10am - 11:25am</td>
<td>Jerry McManus, Suzana De Camargo</td>
<td>4.50</td>
<td>49/50</td>
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<tr>
<td>EESC 2100</td>
<td>001/13062</td>
<td>T 4:10pm - 7:00pm</td>
<td>Jerry McManus, Suzana De Camargo</td>
<td>4.50</td>
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EESC UN2200 EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH. 4.50 points.
CC/GS: Partial Fulfillment of Science Requirement
Priority given to Columbia and Barnard earth science, environmental science, and environmental biology majors should enrollment limits be necessary.
Prerequisites: high school algebra and chemistry. Recommended preparation: high school physics.
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 2023: EESC UN2200

<table>
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<tr>
<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
<th>Instructor</th>
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<tr>
<td>EESC 2200</td>
<td>001/11150</td>
<td>T Th 2:40pm - 3:55pm</td>
<td>Steven Goldstein,</td>
<td>4.50</td>
<td>55/53</td>
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<tr>
<td></td>
<td></td>
<td>603 Schermerhorn Hall</td>
<td>Sidney Hemming, Sedelia Rodriguez</td>
<td></td>
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<tr>
<td>EESC 2200</td>
<td>001/11150</td>
<td>T 4:10pm - 7:00pm</td>
<td>Steven Goldstein,</td>
<td>4.50</td>
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<td>603 Schermerhorn Hall</td>
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Fall 2023: EESC UN2200

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<tr>
<td>EESC 2200</td>
<td>001/13130</td>
<td>T Th 1:10pm - 2:25pm</td>
<td>John Mutter, Jonathan Kingslake</td>
<td>4.50</td>
<td>70/80</td>
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<tr>
<td>EESC 2200</td>
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<td>Th 4:10pm - 7:00pm</td>
<td>John Mutter, Jonathan Kingslake</td>
<td>4.50</td>
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</table>

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

Fall 2023: EESC UN2330

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<td>John Mutter,</td>
<td>3</td>
<td>111/128</td>
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<tr>
<td></td>
<td></td>
<td>501 Northwest Corner</td>
<td>Jenna Lawrence</td>
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EESC UN3101 Geochemistry for a Habitable Planet. 3 points.
Prerequisites: Any 1000-level or 2000-level EESC course; MATH UN1101 Calculus I and CHEM UN1403 General Chemistry I or their equivalents.
The origin, evolution, and future of our planet, based on the book How to Build a Habitable Planet by Wallace S. Broecker. This course will focus on the geochemical processes that built Earth from solar material, led to its differentiation into continents and ocean, and have maintained its surface at a comfortable temperature. Students will participate in a hands-on geochemistry project at Lamont-Doherty Earth Observatory.

Fall 2023: EESC UN3101

<table>
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<th>Course Number</th>
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<tr>
<td>EESC 3101</td>
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<td>Terry Plank</td>
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</table>

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 2023: EESC UN3901

<table>
<thead>
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<th>Course Number</th>
<th>Section/Call Number</th>
<th>Times/Location</th>
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<td>Sidney Hemming,</td>
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<td>16/40</td>
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<td></td>
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<td>530 Altschul Hall</td>
<td>Jacqueline Austermann</td>
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Fall 2023: EESC UN3901

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<th>Points</th>
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<td>EESC 3901</td>
<td>011/14060</td>
<td>Th 4:10pm - 6:00pm</td>
<td>Jerry McManus, Sidney Hemming</td>
<td>3.00</td>
<td>9/50</td>
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<td></td>
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<td>530 Altschul Hall</td>
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</table>

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

Fall 2023: EESC GU4008

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<tr>
<th>Course Number</th>
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<th>Times/Location</th>
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<tr>
<td>EESC 4008</td>
<td>001/13134</td>
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<td>Lorenzo Polvani</td>
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<tr>
<td></td>
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<td>417 Schermerhorn Hall</td>
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</table>
EESC GU4050 GLOBAL ASSMT-REMOTE SENSING. 3.00 points.
CC/GS: Partial Fulfillment of Science Requirement
Enrollment limited to 24. Priority given to graduate students in the natural sciences and engineering.

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

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

Fall 2023: EESC GU4050
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 4050 001/13135 Th 5:40pm - 6:55pm 417 Schermerhorn Hall Christopher Small 3.00 10/20
EESC 4050 001/13135 F 9:00am - 10:45am 558 Ext Schermerhorn Hall Christopher Small 3.00 10/20

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

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

Spring 2023: EESC GU4085
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 4085 001/11156 T Th 2:40pm - 3:55pm 555 Ext Schermerhorn Hall W Buck 3.00 5/20

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

Fall 2023: EESC GU4113
Course Number Section/Call Number Times/Location Instructor Points Enrollment
EESC 4113 001/13065 T 6:30pm - 8:30pm 506 Schermerhorn Hall Moussallam 4.00 6/15
EESC 4113 001/13065 T Th 8:40am - 9:55am 506 Schermerhorn Hall Moussallam 4.00 6/15

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

An overview of the archives in which evidence of terrestrial paleoclimate is preserved, the approaches to developing and applying proxies of climate from these archives, approaches for constraining the time represented by the information, and interpretations that have been developed from such archives. Important archives to be included are ice cores, caves, wetlands, lakes, trees, and moraines. The time interval covered will be mostly the last few tens of thousand years, and chronometers based on radiocarbon, U-series and surface exposure dating will be presented. The course will consist of a formal lecture on one day and a recitation on the second day which will emphasize examples and problem solving.
### EESC GU4600 Earth Resources and Sustain DEV. 3.00 points.
**CC/GS: Partial Fulfillment of Science Requirement**

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

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<td>EESC 4600</td>
<td>001/13232</td>
<td>T Th 1:10pm - 2:25pm</td>
<td>Peter Kelemen</td>
<td>3.00</td>
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<tr>
<td>EESC 4925</td>
<td>001/13138</td>
<td>T Th 8:40am - 9:55am</td>
<td>Andreas Thurnherr</td>
<td>3</td>
<td>18/25</td>
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### 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.

### 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.

### Of Related Interest

#### Environmental Science (Barnard)

<table>
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<tr>
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<td>Environmental Science I</td>
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<td>EESC BC1011</td>
<td>Environmental Science II</td>
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<tr>
<td>EESC BC3014</td>
<td>Field Methods in Environmental Science</td>
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<tr>
<td>EESC BC3016</td>
<td>ENVIRONMENTAL MEASUREMENTS</td>
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<td>EESC BC3017</td>
<td>ENVIRONMENTAL DATA ANALYSIS</td>
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<td>EESC BC3025</td>
<td>HYDROLOGY</td>
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<td>EESC BC3033</td>
<td>Waste Management</td>
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<td>EESC BC3050</td>
<td>BIG DATA WITH PYTHON</td>
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<td>EESC BC3200</td>
<td>Ecotoxicology</td>
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<tr>
<td>EESC BC3300</td>
<td>WORKSHOP SUSTAINABLE DEVELOPMENT</td>
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#### Physics

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<tr>
<td>PHYS UN1018</td>
<td>WEAPONS OF MASS DESTRUCTION</td>
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#### Generally Alternate Year Courses

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<td>DINOSAURS AND HISTORY OF LIFE</td>
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<tr>
<td>EESC UN1201</td>
<td>Environmental Risks and Disasters</td>
</tr>
<tr>
<td>EESC UN1401</td>
<td>DINOSAURS &amp; HISTORY OF LIFE-LEC</td>
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<tr>
<td>EESC UN3015</td>
<td>The Earth’s Carbon Cycle</td>
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<td>EESC GU4009</td>
<td>CHEMICAL GEOLOGY</td>
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<tr>
<td>EESC GU4040</td>
<td>CLIM THERMODYN/ENERGY TRANSFER</td>
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<tr>
<td>EESC GU4085</td>
<td>GEODYNAMICS</td>
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<tr>
<td>EESC GU4113</td>
<td>INTRODUCTION TO MINERALOGY I</td>
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<tr>
<td>EESC GU4330</td>
<td>Introduction to Terrestrial Paleoclimate</td>
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<tr>
<td>EESC GU4223</td>
<td>SEDIMENTARY GEOLOGY</td>
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<td>THE EARTH’S DEEP INTERIOR</td>
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<tr>
<td>EESC GU4630</td>
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<tr>
<td>EESC GU4701</td>
<td>Introduction to Igneous Petrology</td>
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<td>EESC GU4835</td>
<td>Wetlands and Climate Change</td>
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<td>EESC GU4885</td>
<td>CHEMISTRY OF CONTINENTAL WATERS</td>
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<td>EESC GU4888</td>
<td>Stable Isotope Geochemistry</td>
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<td>EESC GU4920</td>
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<td>EESC GU4926</td>
<td>INTRO TO CHEMICAL OCEANOGRAPHY</td>
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<td>EESC GU4937</td>
<td>CENOZOIC PALEOCENOGRAPHY</td>
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<td>Mixing and Dispersion in the Ocean</td>
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<tr>
<td>EESC GU4949</td>
<td>Introduction to Seismology</td>
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<tr>
<td>EESC GR6111</td>
<td>Modern analytical methods in geochemistry</td>
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<td>EESC GR6701</td>
<td>Igneous and metamorphic processes during the creation and evolution of the tectonic plates</td>
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<td>EESC GR6810</td>
<td>The Carbon Cycle</td>
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<tr>
<td>EESC GR6901</td>
<td>Research Computing for the Earth Sciences</td>
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<tr>
<td>EESC GR6909</td>
<td>Advanced Time Series Analysis</td>
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<td>EESC GR6920</td>
<td>DYNAMICS OF CLIMATE</td>
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