THE UNIVERSITY OF CHICAGO
DEPARTMENT OF THE GEOPHYSICAL SCIENCES
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2025-26 Course Offerings

The following courses will be offered by the Department of the Geophysical Sciences for the 2024-25 Academic Year. This list is current as of March 21, 2024. Course offerings are subject to change.

Autumn 2025

GEOS 13300 : The Atmosphere

This course introduces the physics, chemistry, and phenomenology of the Earth's atmosphere, with an emphasis on the fundamental science that underlies atmospheric behavior and climate. Topics include (1) atmospheric composition, evolution, and structure; (2) solar and terrestrial radiation in the atmospheric energy balance; (3) the role of water in determining atmospheric structure; and (4) wind systems, including the global circulation, and weather systems.

Preference will be given to Geosci and Environmental Sci majors/prospective majors. If you are a prospective major, please include this information in your consent request.

Prerequisites:
MATH 13100-MATH 13200

Cross Listings:
ENSC 13300
ENST 13300

Instructor(s):
T. Shaw; N. Nakamura, P. Hassanzadeh

PHSC 13400 : Global Warming: Understanding the Forecast

The future of human civilization depends on its ability to avoid, or adapt to, climate change associated with fossil-fuel (carbon) emissions. With so much at stake, it is important that citizens of the world understand the science which forms the foundation of what is understood about

global climate change. The learning objectives of this course are to develop understanding of: (1) the historical and pre-historical records of global climate change, (2) the Earth's carbon budget, (3) how the greenhouse effect determines temperature in Earth's atmosphere and at the land and sea surface, (4) how climate projections are made, and (5) how present-day activities, both in the scientific research realm and in the socio-economic/political realm are shaping what will happen in the future. Course activity is partitioned into lectures (given by the course instructor), weekly laboratory-section activity (run by graduate teaching assistants), outside reading, and occasional homework. Assessment leading to a course grade will focus primarily on student performance in completing laboratory exercises and on a midterm and final exam. (L)

Prerequisites:

Cross Listings:
ENSC 13400
ENST 12300
GEOS 13400

Instructor(s):
D. MacAyeal

GEOS 21000 : Mineralogy

This course covers structure, chemical composition, stability, and occurrence of major rock-forming minerals. Labs concentrate on mineral specimen identification and optical microscopy. (L)

Prerequisites:
CHEM 10100 & 10200 or equivalent

Cross Listings:
GEOS 31000

Instructor(s):
D. Heinz

GEOS 21205 : Introduction to Seismology, Earthquakes, and Near-Surface Earth Seismicity

This course introduces the mechanics and phenomenology of elastic waves in the Earth and in the fluids near the Earth's surface (e.g., S and P waves in the solid earth, acoustic waves in the ocean and atmosphere). Topics include stress and strain, constitutive equations, elasticity, seismic waves, acoustic waves, theory of refraction/reflection, surface waves, dispersion, and normal modes of the Earth. Phenomenology addressed includes exploration geophysics (refraction/reflection seismology), earthquakes and earthquake source characterization,

seismograms as signals, seismometers and seismological networks, and digital seismogram analysis.

Prerequisites:

Cross Listings:
GEOS 31205

Instructor(s):
S. Park

GEOS 22200 : Geochronology

This course covers the duration of planetary differentiation and the age of the Earth (i.e., extinct and extant chronometers); timescales for building a habitable planet (i.e., the late heavy bombardment, the origin of the atmosphere, the emergence of life, and continent extraction); dating mountains (i.e., absolute ages, exposure ages, and thermochronology); the climate record (i.e., dating layers in sediments and ice cores); and dating recent artifacts (e.g., the Shroud of Turin). (L)

Prerequisites:
Background in college-level geology, physics, and mathematics

Cross Listings:
GEOS 32200

Instructor(s):
N. Dauphas

GEOS 22600 : Topics in Earth Science: The Accretion of Extraterrestrial Matter Throughout Earth's History

This course will provide a discussion of the nature and variability of extraterrestrial (ET) matter accreted throughout Earth's history that is preserved in the geological record. This record is a rich archive of ET matter whose study not only provides unique insight into the origin and evolution of different Solar System objects but also enables a better understanding of delivery mechanisms. The course will highlight periods of dramatically increased accretion rates and important impact events. This includes events such as the recent Chelyabinsk and Tunguska air blasts, the "global killer" Chicxulub impact 66 Ma ago, the Ordovician meteorite showers, all the way to cataclysmic events that occurred on early Earth. The course will also provide an introduction to related key techniques such as classification with material from the meteorite collection, the identification of impact craters, and the use of tracers of ET material in the geological record.

Prerequisites:
Background in college-level geology and mineralogy or consent of instructor

Cross Listings:
GEOS 32600

Instructor(s):
P. Heck

GEOS 23900 : Environmental Chemistry

The focus of this course is the fundamental science underlying issues of local and regional scale pollution. In particular, the lifetimes of important pollutants in the air, water, and soils are examined by considering the roles played by photochemistry, surface chemistry, biological processes, and dispersal into the surrounding environment. Specific topics include urban air quality, water quality, long-lived organic toxins, heavy metals, and indoor air pollution. Control measures are also considered. This course is part of the College Course Cluster program: Climate Change, Culture, and Society.

Prerequisites:
CHEM 11100-11200 or equivalent, and prior calculus course

Cross Listings:
ENSC 23900
ENST 23900
GEOS 33900

Instructor(s):
D. Archer

GEOS 24230 : Geophysical Fluid Dynamics: Foundations

This course is for incoming graduate students in physical sciences intending to take further courses in geophysical fluid dynamics, fluid dynamics, condensed matter physics, and other areas requiring this fundamental skill set. It sets the stage for follow-on courses that present the detail of the behavior of fluids and continuums in geophysical, physical, chemical, and other settings. The material may be a student's first contact with continuum mechanics or a remedial or review for students who have previously taken similar courses. Topics include description of material properties in a continuum, including displacement, velocity, and strain rate; scalar, vector, and tensor properties of continuums, strain, strain rate, and stress; derivations and understanding of mass, momentum, and energy conservation principles in a continuum; applications of conservation principles to simple rheological idealizations, including ideal fluids and potential flow, viscous fluids and Navier-Stokes flow, elasticity and deformation; introductory asymptotic analysis, Reynolds number; heat transfer by conduction and convection, convective instability, Rayleigh number; fluids in gravitational fields, stratification,

buoyancy; elliptic, parabolic, and hyperbolic partial differential equations, typical properties of each

Prerequisites:
Vector calculus, linear algebra, advanced classical mechanics, basic knowledge of computing. Undergrads who take this course should intend to complete a second fluid-dynamics course in Geophysical Sciences.

Cross Listings:
GEOS 34230

Instructor(s):
N. Nakamura

GEOS 26300 : Invertebrate Paleobiology and Evolution

This course provides a detailed overview of the morphology, paleobiology, evolutionary history, and practical uses of the invertebrate and microfossil groups commonly found in the fossil record. Emphasis is placed on understanding key anatomical and ecological innovations within each group and interactions among groups responsible for producing the observed changes in diversity, dominance, and ecological community structure through evolutionary time. Labs supplement lecture material with specimen-based and practical application sections. An optional field trip offers experience in the collection of specimens and raw paleontological data. Several "Hot Topics" lectures introduce important, exciting, and often controversial aspects of current paleontological research linked to particular invertebrate groups. (L)

Prerequisites:
GEOS 13100 and 13200 or equivalent; completion of the general education requirement in the Biological Sciences, or consent of instructor.

Cross Listings:
BIOS 23261
EVOL 32400
GEOS 36300

Instructor(s):
M. Webster

GEOS 26650 : Environmental Microbiology

The objective of this course is to understand how microorganisms alter the geochemistry of their environment. The course will cover fundamental principles of microbial growth, metabolism, genetics, diversity, and ecology, as well as methods used to study microbial communities and activities. It will emphasize microbial roles in elemental cycling, bioremediation, climate, and

ecosystem health in a variety of environments including aquatic, soil, sediment, and engineered systems.

Prerequisites:
CHEM 11100-11200 and BIOS 20186, BIOS 20197, or BIOS 20198

Cross Listings:
ENSC 24500
GEOS 36650

Instructor(s):
M. Coleman

GEOS 30200 : Introduction to Research in the Geophysical Sciences

This course is mandatory for all incoming graduate students in the department. Its purpose is to introduce the faculty's current research themes/areas and to familiarize incoming graduate students with research areas they might contemplate for further specialization. Lectures are presented by individual faculty on either 1) a general survey of a research area, or 2) a specialized topic of interest. Student activity varies from year to year and is based on a combination of oral and written presentations.

Prerequisites:

Cross Listings:

Instructor(s):
Staff

GEOS 33825 : Topics in Microbial Biogeochemistry

In this seminar we explore the role of microorganisms in biogeochemical cycles. Topics include microbial metabolism, physiology, ecology and evolution in natural habitats, responses to short- and long-term climate change, and coevolution of life and its environment over Earth history. Can be taken multiple times for credit since the specific topic will change each quarter.

Prerequisites:

Cross Listings:

Instructor(s):
M. Coleman; J. Waldbauer

GEOS 36900 : Topics in Paleobiology

In this seminar we investigate paleobiological or multidisciplinary topics of current interest to students and faculty. Previous subjects include the origin of phyla, historical and macro-ecology, the stratigraphic record and evolutionary patterns, and climate and evolution.

Prerequisites:

Cross Listings:
ECEV 36900
EVOL 31900

Instructor(s):
D. Jablonski; S. Kidwell; G. Slater

Winter 2026

GEOS 13200 : Earth History

This courses covers principles of historical inference in Earth science; the physical, chemical, and biological data that are used to reconstruct Earth history; and the geographic, biotic, and environmental development of Earth. Weekly labs focus on observation and interpretation of sedimentary rocks and fossil assemblages in hand samples. (L)

Prerequisites:

Cross Listings:
GEOS 13100

Instructor(s):
M. Foote; G. Slater

GEOS 13900 : Biological Evolution

This course is an introduction to evolutionary processes and patterns in present-day organisms and in the fossil record and how they are shaped by biological and physical forces. Topics emphasize evolutionary principles. They include DNA and the genetic code, the genetics of populations, the origins of species, and evolution above the species level. We also discuss major events in the history of life, such as the origin of complex cells, invasion of land, and mass extinction. This course is part of the College Course Cluster program: Climate Change, Culture and Society.

Prerequisites:
BIOS 10130 or BIOS 10140

Cross Listings:
GEOS 13100

Instructor(s):
D. Jalonski

CCSG 20100 : Climate and Sustainable Development: The Science of Climate Change

This course covers the basics of the science of climate change, combining the materials covered in the courses Global Warming (PHSC 13400/13410) and Global Biogeochemical Cycles (GEO 23800). The idea behind this course is to give non-science students sufficient background on the science of climate change to be able to think intelligently about climate impacts, policies and so forth. This course may also consider solar radiation management as a tool for controlling some of the effects of climate change.

Prerequisites:

Cross Listings:

Instructor(s):
N. Nakamura, B.B. Cael

GEOS 23205 : The Cryosphere: Glaciers and Ice Sheets

The fundamentals of glacier and ice-sheet dynamics and phenomenology will be covered in this introductory course (snow and sea ice will be excluded from this course, however may be taken up in the future). Emphasis will be placed on developing the foundation of continuum mechanics and viscous fluid flow as a means of developing the basic equations of glacier deformation, ice-sheet and -shelf flow, basal processes, glacier hydrology, and unstable modes of flow. This course is intended for advanced undergraduate students in physics, math, geophysical sciences, and related fields as well as graduate students considering research in glaciology and climate dynamics. This course is part of the College Course Cluster program: Climate Change, Culture, and Society.

Prerequisites:
Knowledge of vector calculus, linear algebra, and computer programming.

Cross Listings:
GEOS 33205

Instructor(s):
M. Ranganathan

GEOS 24240 : Geophysical Fluid Dynamics: Rotation and Stratification

This course is an introduction to geophysical fluid dynamics for upper-level undergraduates and starting graduate students. The topics covered will be the equations of motion, the effects of rotation and stratification, shallow water systems and isentropic coordinates, vorticity and potential vorticity, and simplified equations for the ocean and atmosphere.

Prerequisites:
PQ: GEOS 24230 or equivalent; Knowledge of mechanics (PHYS 13100 or equivalent), thermodynamics (PHYS 19700 or equivalent), vector calculus and linear algebra (MATH 20000-20100-20200 or equivalent)

Cross Listings:
GEOS 34240

Instructor(s):
M. Jansen

GEOS 24300 : Paleoclimatology

This course will cover the theory and reconstruction of the evolution of Earth's climate through geologic time. After reviewing fundamental principles that control Earth's climate, the course will consider aspects of the climate reconstructions that need to be explained theoretically, such as the faint young sun paradox, snowball Earth episodes, Pleistocene glacial/interglacial cycles, and long-term Cenozoic cooling. Then we will switch to a temporal point of view, the history of Earth's climate as driven by plate tectonics and biological evolution, and punctuated by mass extinctions. This will allow us to place the theoretical ideas from the first part of the course into the context of time and biological progressive evolution.

Prerequisites:
One quarter of chemistry

Cross Listings:
GEOS 34300

Instructor(s):
D. Archer

GEOS 24550 : Ocean Circulation

In this course we discuss the dynamics of the global-scale ocean circulation, which plays an important role in the climate system via the transport and storage of heat and carbon. Topics include the wind-driven ocean gyres, the ocean's thermocline, the turbulent Antarctic

Circumpolar Current as a critical connector of the major ocean basins, as well as the meridional overturning circulation. The course aims to promote a fundamental understanding of ocean dynamics, rather than a purely empirical treatment, and hence builds on the fluid dynamical equations that govern the oceanic motions. The structure of the course includes a combination of lectures, in-class exercises, and discussion of material read by the students at home. The course is suitable for graduate students and upper-level undergraduates.

Prerequisites:
Prerequisite(s): GEOS 24230/34230 and GEOS 24240/34240, or consent of instructor. Knowledge of vector calculus, linear algebra, and ordinary differential equations is assumed.

Cross Listings:
GEOS 34550

Instructor(s):
M. Jansen

GEOS 25400 : Intro to Numerical Techniques for Geophysical Sciences

This course provides an introduction to different types of numerical techniques used in developing models used in geophysical science research. Topics will include how to interpolate and extrapolate functions, develop functional fits to data, integrate a function, or solve partial differential equations. Students are expected to have some familiarity with computers and programming—programming methods will not be discussed in detail. While techniques will be the focus of the course, we will also discuss the planning needed in developing a model as well as the limitations inherent in such models.

Prerequisites:

Cross Listings:
GEOS 35400

Instructor(s):
F. Ciesla

GEOS 26310 : Quantitative Paleontology I: Specimen-Based Analysis of the Fossil Record

This course shows how the application of quantitative analytical techniques to specimen-based paleontology can improve our understanding of the fossil record and permit rigorous investigation of evolutionary and paleoecological questions. Through a combination of introductory lectures, discussion-based seminars, and practical exercises, the course explores fundamental and cutting-edge topics in paleontology including: morphometric analysis of fossil form; systematics; development and evolution (paleo-evo-devo); paleoecology, biofacies, and paleoenvironmental gradients; stratigraphic paleobiology; and quantitative biostratigraphy.

Students will delve into the theory underpinning each topic, and gain hands-on experience with the analytical methods used to interrogate the fossils in their paleoenvironmental and stratigraphic setting.

Prerequisites:
GEOS 26300 Invertebrate Paleobiology and Evolution.

Cross Listings:
GEOS 36310

Instructor(s):
M. Webster

GEOS 32090 : Recent Advances in the Origins of Life

Learn about the recent advances in the search for the origins of life.

Prerequisites:

Cross Listings:

Instructor(s):
F. Ciesla

GEOS 33850 : **Low Temperature Geochemistry**

This course covers topics related to the geochemistry of Earth's surface, including all its fluid and solid components. Specific emphasis will be placed on stable isotopic tools for understanding modern Earth system processes and the ancient geological record. Seminar format will allow students to choose topics of interest to them and shape the reading and discussion content of the course.

Prerequisites:

Cross Listings:
ENSC 33850

Instructor(s):
Clara Blättler

GEOS 34260 : Radiative Transfer and Climate Sensitivity

There has been significant progress recently in our fundamental understanding of how the spectral properties of greenhouse gases (specifically CO2 and water vapor) control radiative forcing and feedbacks and ultimately "clear sky" climate sensitivity (i.e. climate sensitivity in the absence of clouds, which complicate the picture far beyond what can plausibly be covered in this class). The main goal of this class is to read, discuss, and evaluate this recent literature. To enable an informed discussion, the course will start with a general introduction of thermodynamics, climate feedbacks, and radiation, including the Schwarzschild equations for radiative transfer. We will also introduce numerical models that solve the radiative transfer equations for an atmospheric column in radiative-convective equilibrium, ranging from simple gray radiative transfer models to more sophisticated spectrally-resolved algorithms that are used in state-of-the-art climate models. Equipped with these tools, we will read and discuss recent papers that introduce analytical models for the radiative response to CO2 forcing. We will also compare the predictions from these analytical models to more complex numerical solutions.

Prerequisites:
Advanced undergraduate level knowledge of electromagnetic theory, atomic structure, and differential equations.

Cross Listings:
GEOS 24260

Instructor(s):
D. Abbot, M. Jansen

GEOS 34270 : Air Quality and Climate Change

Human activities since the industrial revolution have led to a sharp increase in greenhouse gases and air pollutants. These emissions, after undergoing chemical and physical processes in the atmosphere, cause air pollution and global warming. This course explores the sources, transformations, and fates of key atmospheric constituents and the underlying interactions between atmospheric science and climate change. Topics covered include: atmospheric composition, chemical forcing of climate, stratospheric ozone, tropospheric pollution, atmospheric methane, atmospheric aerosols, and solar geoengineering. The course is appropriate for graduate students and upper-level undergraduates.

Prerequisites:
CHEM 11100-11200 or equivalent

Cross Listings:

Instructor(s):
M. Wang

GEOS 36900 : Topics in Paleobiology

In this seminar we investigate paleobiological or multidisciplinary topics of current interest to students and faculty. Previous subjects include the origin of phyla, historical and macro-ecology, the stratigraphic record and evolutionary patterns, and climate and evolution.

Prerequisites:

Cross Listings:
ECEV 36900
EVOL 31900

Instructor(s):
D. Jablonski; S. Kidwell; G. Slater

GEOS 36905 : Topics in Conservation Paleobiology

Paleobiological data from very young sedimentary records, including skeletal 'death assemblages' actively accumulating on modern land surfaces and seabeds, provide unique information on the status of present-day populations, communities, and biomes and their responses to natural and anthropogenic stress over the last few decades to millennia. This course on the emerging discipline of ‘conservation paleobiology’ uses weekly seminars and individual research projects to introduce how paleontologic methods, applied to modern samples, can address critical issues in the conservation and restoration of biodiversity and natural environments, including such basic questions as ‘has a system changed, and if so how and when relative to suspected stressors?’. The course will include hands-on experience, either in the field or with already-collected marine benthic samples, to assess societally relevant ecological change in modern systems over time-frames beyond the reach of direct observation. Enrollment limited.

Prerequisites:
For undergraduates: completion of GEOS 13100-13200-13300 or equivalent or completion of a 20000 level course in Palentology.

Cross Listings:
EVOL 36905
GEOS 26905

Instructor(s):
S. Kidwell

Topics in Cosmo Chem: presolar grains and nucleosynthesis

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Prerequisits:

Cross Listings:

Instructor(s):

Spring 2026

PHSC 11000 : Environmental History of the Earth

This course considers how physical and biological processes determine environmental conditions at the surface of the Earth, and how environments have changed over the 4.5 billion-year history of Earth. Topics include the methods of historical inference in geology; major transitions in the history of life, including the origin of life, the evolution of oxygen-producing photosynthesis, the origin of animals, and the series of massive extinctions that have repeatedly re-set ecosystems both on land and in the sea; and ecosystem evolution, including the environmental effects of human evolution. Labs involve hands-on study of rock and fossil specimens, and analysis and interpretation of datasets drawn from the scientific literature and/or faculty research programs. (L)

Prerequisites:

Cross Listings:

Course Description Notes:

Due to significant overlap of course content, students may register for only one of PHSC 11000, BIOS 12117, or GEOS 13900/BIOS 13123

Instructor(s):

M. Webster; S. Kidwell

GEOS 25600 : Getting Something for Nothing

We can learn an incredible amount about the physical world with simple tools of estimation. So-called Fermi problems involve estimating quantities of interest to within an order of magnitude, or factor of 10, on the “back of an envelope.” There are leanable techniques that we can use to approach these problems. Developing these skills is incredibly useful for physical scientists because it allows us to quickly estimate whether an idea is worth pursuing with expensive

resources and time. More generally, order-of-magnitude estimation can keep you from getting fooled by journalists and politicians, or give you a trading edge in a competitive market. Finally, Fermi problems are common in interviews for jobs in finance, consulting, and software. Students in this course will develop techniques to quickly estimate physical science quantities to within an order of magnitude.

Prerequisites:

Cross Listings:
GEOS 11900

Instructor(s):
D. Abbot

GEOS 13300 : The Atmosphere

This course introduces the physics, chemistry, and phenomenology of the Earth's atmosphere, with an emphasis on the fundamental science that underlies atmospheric behavior and climate. Topics include (1) atmospheric composition, evolution, and structure; (2) solar and terrestrial radiation in the atmospheric energy balance; (3) the role of water in determining atmospheric structure; and (4) wind systems, including the global circulation, and weather systems.

Preference will be given to Geosci and Environmental Sci majors/prospective majors. If you are a prospective major, please include this information in your consent request.

Prerequisites:
MATH 13100-MATH 13200

Cross Listings:
ENSC 13300
ENST 13300

Instructor(s):
T. Shaw, N. Nakamura, P. Hassanzadeh

PHSC 13410 : Global Warming: Understanding the Forecast (Flipped Class)

This course presents the science behind the forecast of global warming to enable the student to evaluate the likelihood and potential severity of anthropogenic climate change in the coming centuries. It includes an overview of the physics of the greenhouse effect, including comparisons with Venus and Mars; predictions and reliability of climate model forecasts of the greenhouse world. This course is part of the College Course Cluster program, Climate Change, Culture, and

Society. This course covers the same material as PHSC 13400, but is organized using a flipped classroom approach in order to increase student engagement and learning.

Prerequisites:

Cross Listings:
ENSC 13410
ENST 13410
GEOS 13410

Instructor(s):
D. Abbot

GEOS 21100 : Introduction to Petrology

Students in this course learn how to interpret observable geological associations, structures, textures, and mineralogical and chemical compositions of rocks so as to develop concepts of how they form and evolve. Our theme is the origin of granitic continental crust on the only planet known to have oceans and life. Igneous, sedimentary, and metamorphic rocks; ores; and waste disposal sites are reviewed. (L)

Prerequisites:
GEOS 21000 is strongly recommended.

Cross Listings:

Instructor(s):
N. Dauphas

GEOS 23600 : Chemical Oceanography

This course explores the chemistry of the ocean system and its variations in space and time. The oceans play an essential role in most (bio)geochemical cycles, interacting in various ways with the atmosphere, sediments, and crust. These interactions can be understood through studying the geochemical and isotopic properties of the ocean, its inputs and outputs, and its evolution as recorded in marine sediments and sedimentary rocks. Topics include: the marine carbon cycle, nutrient cycling, chemical sediments, and hydrothermal systems.

Prerequisites:
Completion of one of the following Chemistry Sequences: CHEM 10100-10200-11300 Introductory General Chemistry I-II; Comprehensive General Chemistry III or CHEM 11100-11200-11300 Comprehensive General Chemistry I-II-III or CHEM 12100-12200-12300 Honors General Chemistry I-II-III AND either GEOS 13100 or GEOS 13200.

Cross Listings:

CHEM 23600
ENSC 23600
GEOS 33600

Instructor(s):
C. Blättler

GEOS 23800 : Global Biogeochemical Cycles

This survey course covers the geochemistry of the surface of the Earth, focusing on biological and geological processes that shape the distributions of chemical species ,in the atmosphere, oceans and terrestrial habitats. Budgets and cycles of carbon, nitrogen, oxygen, phosphorous, and sulfur are discussed, as well as chemical fundamentals of metabolism, weathering, acid-base and dissolution equilibria, and isotopic fractionation. The course examines the central role that life plays in maintaining the chemical disequilibira that characterize Earth's surface environments. The course also explores biogeochemical cycles change (or resist change) over time, as well as the relationships between geochemistry, biological (including human) activity, and Earth's climate.

Prerequisites:
CHEM 11100-11200 or consent of instructor

Cross Listings:
ENSC 23800
GEOS 33800

Instructor(s):
J. Waldbauer

GEOS 24250 : Geophysical Fluid Dynamics: Understanding the Motions of the Atmosphere and Oceans

This course is part of the atmospheres and oceans sequence (GEOS 24220, 24230, 24240, 24250) and is expected to follow Geophysical Fluid Dynamics: Rotation and Stratification (GEOS 24240). The course demonstrates how the fundamental principles of geophysical fluid dynamics are manifested in the large-scale circulation of the atmosphere and oceans and their laboratory analogs. Topics include: balance of forces and the observed structure of the atmospheric and oceanic circulations, statistical description of the spatially and temporally varying circulation, theory of Hadley circulation, waves in the atmosphere and oceans, baroclinic instability, wind-driven ocean circulation.

Prerequisites:
GEOS 24230 and 24240, or consent of the instructor. Knowledge of vector calculus, linear algebra, and ordinary differential equations is assumed.

Cross Listings:

GEOS 34250

Instructor(s):
N. Nakamura, D. Yang

GEOS 24550 : Ocean Circulation

In this course we discuss the dynamics of the global-scale ocean circulation, which plays an important role in the climate system via the transport and storage of heat and carbon. Topics include the wind-driven ocean gyres, the ocean's thermocline, the turbulent Antarctic Circumpolar Current as a critical connector of the major ocean basins, as well as the meridional overturning circulation. The course aims to promote a fundamental understanding of ocean dynamics, rather than a purely empirical treatment, and hence builds on the fluid dynamical equations that govern the oceanic motions. The structure of the course includes a combination of lectures, in-class exercises, and discussion of material read by the students at home. The course is suitable for graduate students and upper-level undergraduates.

Prerequisites:
Prerequisite(s): GEOS 24230/34230 and GEOS 24240/34240, or consent of instructor. Knowledge of vector calculus, linear algebra, and ordinary differential equations is assumed.

Cross Listings:
GEOS 34550

Instructor(s):
M. Jansen

GEOS 24810 : Removing Carbon Dioxide from the Atmosphere

This class will survey the science of removing fossil fuel carbon dioxide from the atmosphere, using industrial equipment or by altering soils or natural waters. The various potential strategies have different capacities, costs, and environmental impacts, and some are more verifiable than others. We will evaluate them within the context of the geochemistry of groundwaters and the oceans, and Earth's changing climate and carbon cycle, to get a picture of just how big a pickle we are in.

Prerequisites:
Familiarity with chemistry will be helpful.

Cross Listings:

Instructor(s):

GEOS 35500 : Scientific machine learning for climate and chaos

This course is intended to be a brief introduction to mathematical methods that may be of use in the Earth Sciences. The focus will be on building physical intuition and practical problem solving. Students may solve problems analytically, or write numerical codes to solve them.

Prerequisites:

Cross Listings:
GEOS 25500

Instructor(s):
D. Abbot, P. Hassanzadeh

GEOS 26320 : Quantitative Paleontology II: Analysis of taxonomic data

This course explores some of the principal ways in which data on taxonomic occurrences and stratigraphic ranges, along with morphological and other ancillary data, can be analyzed to draw inferences regarding evolution in the fossil record. Topics include basic probability theory; evolutionary sequences within single lineages; birth-death models; and models of incomplete sampling. Course goals will be met through a combination of lectures; reading and discussion of key papers; and exercises to develop code and analyze empirical data.

Prerequisites:
GEOS 26310/36310 Quantitative Paleontology I: Specimen-Based Analysis of the Fossil Record

Cross Listings:

Instructor(s):
M Foote, G. Slater

GEOS 29002 : Field Course in Modern and Ancient Environments

This course, in its many iterations, has had consistent aims: to provide students with hands-on experience of the processes that produce sedimentary rocks, exposure to standard field methods and fieldwork safety, and experience in developing and conducting an original research project. We consider biological as well as physical processes of sediment production, dispersal, accumulation, and post-depositional modification, and methods of paleoenvironmental analysis. We give significant attention to humans as geological agents: field areas today almost always exhibit legacy and/or ongoing effects from human activities. This year we explore the theme of Coasts and Coastal Resilience, using Lake Michigan shorelines as exemplars of coastal responses to key forcers — water (wave) regime, water level, and sediment supply — on societally relevant time scales. The spectrum of environments will include built structures such as seawalls, jetties, and hardened shorelines, and both natural and engineered “soft” shorelines. We will meet on Tuesdays and Thursdays 3:30-5:00, with approximately half devoted to lectures and discussion, and the other half to labs, which will be either indoors (using research wave

tanks in Hinds) or outdoors (using nearby segments of the Lake Michigan shoreline). A day-long Saturday field excursion is also possible.

Prerequisites:
GEOS 13100 and 13200 recommended; contact instructor

Cross Listings:
CHST 29002
ENSC 29002

Instructor(s):
S. Kidwell

GEOS 31250 : Topics in Seismology

In this seminar, we discuss seismological and multidisciplinary topics. Topics include, but are not limited to: seismic imaging techniques, planetary seismology, environmental seismology, deep earthquakes and other emerging subjects in seismology. The specific focus for each class offering will be determined by the interests of the faculty and students. Can be taken multiple times for credit since the specific topic will change each quarter.

Prerequisites:
GEOS 21205/31205 or permission of instructor

Cross Listings:

Instructor(s):
S. Park

GEOS 33300 : Advanced Topics in Climate Dynamics

The course will go beyond radiative-convective equilibrium and explore spatial and temporal aspects of Earth's climate with a focus on the atmosphere. The goal is to gain a physical understanding of Earth's climate and its past and future changes. We will discuss a range of topics from the surface and atmospheric energy balance, hydrological cycle, atmospheric general circulation and energy transport, climate variability, paleoclimate, natural & anthropogenic climate change. The course will combine lectures of the theory and observations underlying our understanding of Earth's climate with student presentations of peer-reviewed papers. The evaluation will be based on a data-analysis project.

Prerequisites:
GEOS 24220 or equivalent required. GEOS 24230-24240 recommended.

Cross Listings:

Instructor(s):
T. Shaw

GEOS 33950 : Topics in Organic Geochemistry

Topics in Organic Geochemistry

Prerequisites:

Cross Listings:

Instructor(s):

GEOS 34450 : Topics in Aerosols-Cloud-Climate Interactions

The major remaining uncertainty in climate projection comes from aerosol-cloud-climate interactions in the atmosphere. Consequently, an accurate representation of aerosols and clouds is the foundation of any effort to predict long-term climate change. In this seminar, we will discuss topics including, but not limited to: (1) chemical and physical processes driving aerosol and cloud formation; (2) ground-based, airborne, and remote measurements of aerosols and clouds; (3) regional and global modeling of preindustrial and present-day aerosol and cloud state; and (4) model validation and climate assessment for climate system engineering technologies (e.g., stratospheric aerosol injection and marine cloud brightening). Specific topics for each seminar will be determined by faculty and student interests.

Prerequisites:

Cross Listings:

Instructor(s):
M. Wang

GEOS 26300 : Invertebrate Paleobiology and Evolution

This course provides a detailed overview of the morphology, paleobiology, evolutionary history, and practical uses of the invertebrate and microfossil groups commonly found in the fossil record. Emphasis is placed on understanding key anatomical and ecological innovations within each group and interactions among groups responsible for producing the observed changes in diversity, dominance, and ecological community structure through evolutionary time. Labs supplement lecture material with specimen-based and practical application sections. An optional field trip offers experience in the collection of specimens and raw paleontological data. Several "Hot Topics" lectures introduce important, exciting, and often controversial aspects of current paleontological research linked to particular invertebrate groups. (L)

Prerequisites:

GEOS 13100 and 13200 or equivalent; completion of the general education requirement in the Biological Sciences, or consent of instructor.

Cross Listings:
BIOS 23261
EVOL 32400
GEOS 36300

Instructor(s):
M. Webster

GEOS 36800 : Macroevolution

Patterns and processes of evolution above the species level, in both recent and fossil organism. A survey of the current literature, along with case studies.

Prerequisites:

Cross Listings:
EVOL 31700

Instructor(s):
D. Jablonski
Reviewer Notes

Field Courses and Independent Study

GEOS 29002/39002. Field Course in Modern and Ancient Environments.

100 Units. Instructor(s): S. Kidwell; M. LaBarbera
This course uses weekly seminars during Winter Quarter to prepare for a one-week field trip over spring break, where students acquire experience with sedimentary rocks and the modern processes responsible for them, learn field methods, and complete an original research project. We consider biological as well as physical processes of sediment production, dispersal, accumulation, and post-depositional modification. Destinations vary; past trips have examined tropical carbonate systems of Jamaica and the Bahamas and subtropical coastal Gulf of California.

Prerequisites:

Cross Listings:
ENSC 29002,
GEOS 39002

Instructor(s):

Reviewer Notes Note(s): Organizational meeting and deposit usually required in Autumn Quarter; interested students should contact an instructor in advance. Enrollment allowed by permission of instructor.
Equivalent Course(s):

GEOS 29700. Reading and Research in the Geophysical Sciences.

Independent study; regular meetings with Geophysical Sciences faculty member required. Topics available include, but are not limited to: Mineralogy, Petrology, Geophysics, High Pressure Geophysics, Geodynamics, Volcanology, Cosmochemistry, Geochemistry, Atmospheric Dynamics, Paleoclimatology, Physical Oceanography, Chemical Oceanography, Paleoceanography, Atmospheric Chemistry, Fluid Dynamics, Glaciology, Climatology, Radiative Transfer, Cloud Physics, Morphometrics, Phylogeny, Analytical Paleontology, Evolution, Taphonomy, Macroevolution, Paleobiology, Paleobotany, Biomechanics, Paleoecology, Tectonics, Stratigraphy.

Prerequisite(s):
Consent of instructor and departmental counselor

Note(s): Students are required to submit the College Reading and Research Course Form. Available to nonmajors for P/F grading. Must be taken for a quality grade when used to meet a requirement in the major.

Cross Listings:

Instructor(s): Staff

GEOS 39700. Reading and Research in the Geophysical Sciences.

GEOS 39700-39799. Topics available include, but are not limited to: Mineralogy, Petrology, Geophysics, High Pressure Geophysics, Geodynamics, Volcanology, Cosmochemistry, Geochemistry, Atmospheric Dynamics, Paleoclimatology, Physical Oceanography, Chemical Oceanography, Paleoceanography, Atmospheric Chemistry, Fluid Dynamics, Glaciology, Climatology, Radiative Transfer, Cloud Physics, Morphometrics, Phylogeny, Analytical Paleontology, Evolution, Taphonomy, Macroevolution, Paleobiology, Aktuopaleontology, Paleobotany, Biomechanics, Paleoecology, Tectonics, Stratigraphy.

Instructor(s): Staff

Cross Listings:

Prerequisite(s): Admission to graduate status