ENvironmenTal Earth System science

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The objectives of the doctoral program are to enable students to develop the skills needed to conduct original investigations in environmental and earth system sciences, to interpret the results, and to present the data and conclusions in a publishable manner. Graduates should obtain strong communication skills and leadership skills with the ability to teach and communicate effectively with the public.

The University’s requirements for the Ph.D. degree are outlined in the “Graduate Degrees” section of this bulletin. A summary of additional department requirements follows:

1. Students must complete the required courses in their individual program or in their specialized area of study with a grade point average (GPA) of 3.0 (B) or higher, or demonstrate that they have completed the equivalents elsewhere.
2. Students must complete a minimum of four letter grade courses of at least 3 units each from four different faculty members in the department. The research examination consists of three parts: oral presentation of a research proposal; examination on the research proposal; and examination on subject matter relevant to the proposed research. The exam should take place prior to May 1 so that its outcome is known at the time of the annual spring evaluation of graduate students.

Upon qualifying for Ph.D. candidacy, the student and thesis adviser, preparation of a written research proposal, approval of this proposal by the thesis adviser, selection of a committee for the Ph.D. qualifying examination, and approval of the membership by the graduate coordinator and chair of the department. The research examination consists of three parts: oral presentation of a research proposal; examination on the research proposal; and examination on subject matter relevant to the proposed research. The exam should take place prior to May 1 so that its outcome is known at the time of the annual spring evaluation of graduate students.

Under the supervision of the research advisory committee, the
candidate must prepare a doctoral dissertation that is a contribution to knowledge and is the result of independent research; curriculum must also be developed with the supervision of the committee, which should be designed to provide a rigorous foundation for the research area. The format of the dissertation must meet University guidelines. The student is urged to prepare dissertation chapters that, in scientific content and format, are readily publishable.

The doctoral dissertation is defended in the University oral examination. The department appoints the research adviser and two other members of the research committee to be readers of the draft dissertation. The readers are charged to read the draft and to certify in writing to the department that it is adequate to serve as a basis for the University oral examination. Upon obtaining this written certification, the student is permitted to schedule the University oral examination.

ENVIRONMENTAL EARTH SYSTEM SCIENCE (EESS) COURSES

For information on graduate programs in Environmental Earth System Science, see the “Environmental Earth System Science” section of this bulletin.

UNDERGRADUATE COURSES IN ENVIRONMENTAL EARTH SYSTEM SCIENCE

EESS 2. Earth System History
The evolution of Earth’s systems from formation to the present. Couplings and relationships among biosphere, lithosphere, hydrosphere, and atmosphere. Topics include the evolution of life, origin of the oceans, atmosphere and continents, and changes in climate. Modern climate change and anthropogenic effects. GER:DB-NatSci
3 units, Win (Chamberlain, P)

EESS 39N. The Carbon Cycle: Reducing Your Impact
Stanford Introductory Seminar. Preference to freshmen. Changes in the long- and short-term carbon cycle and global climate through the burning of fossil fuels since the Industrial Revolution. How people can shrink their carbon footprints. Long-term sources and sinks of carbon and how they are controlled by tectonics and short-term sources and sinks and the interaction between the biosphere and ocean. How people can shrink their carbon footprints. Held at the Stanford Community Farm. GER:DB-NatSci
3 units, Spr (Chamberlain, P)

EESS 46N. Exploring the Critical Interface between the Land and Monterey Bay: Elkhorn Slough
Stanford Introductory Seminar. Preference to freshmen. Field trips to sites in the Elkhorn Slough, a small agriculturally impacted estuary that opens into Monterey Bay, a model ecosystem for understanding the complexity of estuaries, and one of California’s last remaining coastal wetlands. Readings include Jane Caffrey’s Changes in a California Estuary: A Profile of Elkhorn Slough. Basics of biogeochemistry, microbiology, oceanography, ecology, pollution, and environmental management. 3 units, Spr (Francis, C)

EESS 101. Environmental and Geological Field Studies in the Rocky Mountains
(Same as GES 101.) Three-week, field-based program in the Greater Yellowstone/Teton and Wind River Mountains of Wyoming. Field-based exercises covering topics including: basics of structural geology and petrology; glacial geology; western cordillera geology; paleoclimatology; chemical weathering; aqueous geochemistry; and environmental issues such as acid mine drainage and changing land-use patterns.
3 units, Aut (Chamberlain, P; Graham, S)

EESS 111. Biology and Global Change
(Same as BIO 117, EARTHSYS 111.) The biological causes and consequences of anthropogenic and natural changes in the atmosphere, oceans, and terrestrial and freshwater ecosystems. Topics: glacial cycles and marine circulation, greenhouse gases and climate change, tropical deforestation and species extinctions, and human population growth and resource use. Prerequisite: Biology or Human Biology core or graduate standing. GER:DB-NatSci
4 units, Win (Vitousek, P; Arrigo, K)

EESS 134. Stable Isotopes in Biogeochemistry
(Same as EESS 234.) Light stable isotopes and their application to geological, ecological, and environmental problems. Isotopic systematics of hydrogen, carbon, nitrogen, oxygen, and sulfur; chemical and biogenic fractionation of light isotopes in the atmosphere, hydrosphere, and rocks and minerals. GER:DB-NatSci
3 units, Spr (Chamberlain, P)

EESS 141. Remote Sensing of the Oceans
(Same as EESS 241, EARTHSYS 141, EARTHSYS 241.) How to observe and interpret physical and biological changes in the oceans using satellite technologies. Topics: principles of satellite remote sensing, classes of satellite remote sensors, converting radiometric data into biological and physical quantities, sensor calibration and validation, interpreting large-scale oceanographic features. GER:DB-NatSci
3-4 units, alternate years, not given this year

EESS 143. Marine Biogeochemistry
(Same as EESS 243. Graduate students register for 243.) Processes that control the mean concentration and distribution of biologically utilized elements and compounds in the ocean. Processes at the air-sea interface, production of organic matter in the upper ocean, remineralization of organic matter in the water column, and processing of organic matter in the sediments. Cycles of carbon, oxygen, and nutrients; the role of the ocean carbon cycle in interannual to decadal variability, paleoclimatology, and the anthropogenic carbon budget. GER:DB-NatSci
3-4 units, Spr (Arrigo, K)

EESS 155. Science of Soils
(Same as EESS 255. Graduate students register for 255.) Processes of soil development and soil-forming processes within soil systems. Emphasis is on factors governing nutrient availability, plant growth and production, land-resource management, and pollution within soils. How to classify soils and assess nutrient cycling and contaminant fate. Recommended: introductory chemistry and biology. GER:DB-NatSci
4 units, Spr (Fendorf, S)

EESS 156. Soil Chemistry
(Same as EESS 256. Graduate students register for 256.) Practical and quantitative treatment of soil processes affecting chemical reactivity, transformation, retention, and bioavailability. Principles of primary areas of soil chemistry: inorganic and organic soil components, complex equilibria in soil solutions, and adsorption phenomena at the solid-water interface. Processes and remediation of acid, saline, and wetland soils. Recommended: soil science and introductory chemistry and microbiology. GER:DB-NatSci
4 units, Win (Fendorf, S)
EESS 160. Statistical Methods for Earth and Environmental Sciences: General Introduction
Extracting information from data using statistical summaries and graphical visualization, statistical measures of association and correlation, distribution models, sampling, error estimation and confidence intervals, linear models and regression analysis, introduction to time-series and spatial data with geostatistics, applications including environmental monitoring, natural hazards, and experimental design. GER:DB-NatSci
3 units, Spr (Switzer, P)

EESS 161. Statistical Methods for the Earth and Environmental Sciences: Geostatistics
(Same as ENERGY 161.) Statistical analysis and graphical display of data, common distribution models, sampling, and regression. The variogram as a tool for modeling spatial correlation; variogram estimation and modeling; introduction to spatial mapping and prediction with kriging; integration of remote sensing and other ancillary information using co-kriging models; spatial uncertainty; introduction to geostatistical software applied to large environmental, climatological, and reservoir engineering databases; emphasis is on practical use of geostatistical tools. GER:DB-NatSci
3-4 units, Win (Boucher, A)

EESS 162. Remote Sensing of Land Use and Land Cover
(Same as EARTHSYS 142, EARTHSYS 242.) The use of satellite remote sensing to monitor land use and land cover, with emphasis on terrestrial changes. Topics include pre-processing data, biophysical properties of vegetation observable by satellite, accuracy assessment of maps derived from remote sensing, and methodologies to detect changes such as urbanization, deforestation, vegetation health, and wildfires.
4 units, not given this year

EESS 164. Fundamentals of Geographic Information Science (GIS)
(Same as EARTHSYS 144.) Survey of geographic information including maps, satellite imagery, and census data, approaches to spatial data, and tools for integrating and examining spatially-explicit data. Emphasis is on fundamental concepts of geographic information science and associated technologies. Topics include geographic data structure, cartography, remotely sensed data, statistical analysis of geographic data, spatial analysis, map design, and geographic information system software. Computer lab assignments. GER:DB-NatSci
4 units, Aut (Reilly, M)

EESS 241. Remote Sensing of the Oceans
(Same as EESS 141, EARTHSYS 141, EARTHSYS 241.) How to observe and interpret physical and biological changes in the oceans using satellite technologies. Topics: principles of satellite remote sensing, classes of satellite remote sensors, converting radiometric data into biological and physical quantities, sensor calibration and validation, interpreting large-scale oceanographic features. GER:DB-NatSci
3-4 units, alternate years, not given this year

GRADUATE COURSES IN ENVIRONMENTAL EARTH SYSTEM SCIENCE
Primarily for graduate students; undergraduates may enroll with consent of instructor.

EESS 253S. Hopkins Microbiology Course
(Same as BIO 274S, BIOHOPK 274, CEE 274S. Formerly GES 274S.) Four-week, intensive. The interplay between molecular, physiological, ecological, evolutionary, and geochemical processes that constitute, cause, and maintain microbial diversity. How to isolate key microorganisms driving marine biological and geochemical diversity, interpret culture-independent molecular characterization of microbial species, and predict causes and consequences. Laboratory component: what constitutes physiological and metabolic microbial diversity; how evolutionary and ecological processes diversify individual cells into physiologically heterogeneous populations; and the principles of interactions between individuals, their population, and other biological entities in a dynamically changing microbial ecosystem. Prerequisites: CEE 274A, B, or equivalents.
9-12 units, Sum (Spormann, A; Francis, C)

EESS 332. Stanford at Sea
(Same as BIOHOPK 182H, BIOHOPK 323H, EARTHSYS 323. Graduate students register for 323H.) Five weeks of marine science including oceanography, marine physiology, policy, maritime studies, conservation, and nautical science at Hopkins Marine Station, followed by five weeks at sea aboard a sailing research vessel in the Pacific Ocean. Shore component comprised of three multidisciplinary courses meeting daily and continuing aboard ship. Students develop an independent research project plan while ashore, and carry out the research at sea. In collaboration with the Sea Education Association of Woods Hole, MA. Only 6 units may count towards the Biology major.
16 units, Spr (Block, B; Dunbar, R; Michel, F), alternate years, not given next year

EESS 158. Geomicrobiology
(Same as EESS 258.) How microorganisms shape the geochemistry of the Earth’s crust including oceans, lakes, estuaries, subsurface environments, sediments, soils, mineral deposits, and rocks. Topics include mineral formation and dissolution; biogeochemical cycling of elements (carbon, nitrogen, sulfur, and metals); geochemical and mineralogical controls on microbial activity, diversity, and evolution; life in extreme environments; and the application of new techniques to geomicrobial systems. Recommended: introductory chemistry and microbiology such as CEE 274A.
3 units, not given this year

EESS 200. Professional Development in Geoscience Education
(Same as GES 200. GEOPHYS 203.) May be repeated for credit.
1 unit, Aut (Payne, J), Spr (Payne, J)

EESS 217. Tectonics, Topography, and Climate Change
(Formerly GES 287.) For upper-division undergraduates and graduate students. The links between tectonics and climate change with emphasis on the Cenozoic era. Focus is on terrestrial climate and how they relate to large-scale tectonics of mountain belts. Topics include stable isotope geochemistry, geochronology, chemical weathering, stratigraphy of terrestrial rocks, paleofauna and flora, climate proxies and records, and Cenozoic tectonics. Guest speakers, student presentations.
3 units, not given this year

EESS 220. Physical Hydrogeology
(Same as CEE 260A. Formerly GES 230.) Theory of underground water occurrence and flow, analysis of field data and aquifer tests, geologic groundwater environments, solution of field problems, and groundwater modeling. Introduction to groundwater contaminant transport and unsaturated flow. Lab. Prerequisite: elementary calculus.
4 units, Aut (Gorelick, S; Walker, K)
EESS 221. Contaminant Hydrogeology
(Same as CEE 260C. Formerly GES 231.) For earth scientists and engineers. Environmental and water resource problems involving contaminated groundwater. The processes affecting contaminant migration through porous media including interactions between dissolved substances and solid media. Conceptual and quantitative treatment of advective-dispersive transport with reacting solutes. Predictive models of contaminant behavior controlled by local equilibrium and kinetics. Modern methods of contaminant transport simulation and optimal aquifer remediation. Prerequisite: GES 230 or CEE 260A or equivalent.
4 units, Spr (Gorelick, S)

EESS 234. Stable Isotopes in Biogeochemistry
(Same as EESS 134.) Light stable isotopes and their application to geological, ecological, and environmental problems. Isotopic systematics of hydrogen, carbon, nitrogen, oxygen, and sulfur; chemical and biogenic fractionation of light isotopes in the atmosphere, hydrosphere, and rocks and minerals.
3 units, Spr (Chamberlain, P)

EESS 240. Advanced Oceanography
For upper-division undergraduates and graduate students in the earth, biologic, and environmental sciences. Topical issues in marine science/oceanography. Topics vary each year following or anticipating current trends in oceanographic research. Focus is on links between the circulation and physics of the ocean with climate in the N. Pacific region, and marine ecologic responses. Participation by marine scientists from research groups and organizations including the Monterey Bay Aquarium Research Institute.
3 units, Aut (Dunbar, R; Long, M)

EESS 242. Antarctic Marine Geology
For upper-division undergraduates and graduate students. Intermediate and advanced topics in marine geology and geophysics, focusing on examples from the Antarctic continental margin and adjacent Southern Ocean. Topics: glaciers, icebergs, and sea ice as geologic agents (glacial and glacial marine sedimentology, Southern Ocean current systems and deep ocean sedimentation), Antarctic biostratigraphy and chronostratigraphy (continental margin evolution). Students interpret seismic lines and sediment core/well log data. Examples from a recent scientific drilling expedition to Prydz Bay, Antarctica. Up to two students may have an opportunity to study at sea in Antarctica during Winter Quarter.
3 units, alternate years, not given this year

EESS 243. Marine Biogeochemistry
(Same as EESS 143. Graduate students register for 243.) Processes that control the mean concentration and distribution of biologically utilized elements and compounds in the ocean. Processes at the air-sea interface, production of organic matter in the upper ocean, remineralization of organic matter in the water column, and processing of organic matter in the sediments. Cycles of carbon, oxygen, and nutrients; the role of the ocean carbon cycle in interannual to decadal variability, paleoclimatology, and the anthropogenic carbon budget.
3-4 units, Spr (Arrigo, K)

EESS 244. Marine Ecosystem Modeling
Practical background necessary to construct and implement a 2-dimensional (space and time) numerical model of a simple marine ecosystem. Computer programming, model design and parameterization, and model evaluation. Students develop and refine their own multi-component marine ecosystem model.
3 units, Spr (Arrigo, K)

EESS 245. Advanced Biological Oceanography
For upper-division undergraduates and graduate students. Themes vary annually but include topics such as marine bio-optics, marine ecological modeling, and phytoplankton primary production. Hands-on laboratory and computer activities, and field trips into local waters. May be repeated for credit. Prerequisite: familiarity with concepts presented in GEOPHYS 130/231 or equivalent. (Arrigo) 3-4 units, Aut (Arrigo, K)

EESS 250. Elkhorn Slough Microbiology
(Formerly GES 270.) The microbial ecology and biogeochemistry of Elkhorn Slough, an agriculturally-impacted coastal estuary draining into Monterey Bay. The diversity of microbial lifestyles associated with estuarine physical/chemical gradients, and the influence of microbial activity on the geochemistry of the Slough, including the cycling of carbon, nitrogen, sulfur, and metals. Labs and field work. Location: Honkins Marine Station.
3 units, Sum (Staff)

EESS 256. Soil Chemistry
(Formerly EESS 156. Graduate students register for 256.) Practical and quantitative treatment of soil processes affecting chemical reactivity, transformation, retention, and bioavailability. Principles of primary areas of soil chemistry: inorganic and organic soil components, complex equilibria in soil solutions, and adsorption phenomena at the solid-water interface. Processes and remediation of acid, saline, and wetland soils. Recommended: soil science and introductory chemistry and microbiology.
4 units, Win (Fendorf, S)

EESS 258. Geomicrobiology
(Same as EESS 158.) How microorganisms shape the geochemistry of the Earth’s crust including oceans, lakes, estuaries, subsurface environments, sediments, soils, mineral deposits, and rocks. Topics include mineral formation and dissolution; biogeochemical cycling of elements (carbon, nitrogen, sulfur, and metals); geochemical and mineralogical controls on microbial activity, diversity, and evolution; life in extreme environments; and the application of new techniques to geomicrobial systems. Recommended: introductory chemistry and microbiology such as CEE 274A.
3 units, not given this year

EESS 259. Environmental Microbial Genomics
The application of molecular and environmental genomic approaches to the study of biogeochemically-important microorganisms in the environment without the need for cultivation. Emphasis is on genomic analysis of microorganisms by direct extraction and cloning of DNA from natural microbial assemblages. Topics include microbial energy generation and nutrient cycling, genome structure, gene function, physiology, phylogenetic and functional diversity, evolution, and population dynamics of uncultured communities.
1-3 units, Win (Francis, C)

EESS 263. Topics in Advanced Geostatistics
(Same as ENERGY 242.) Conditional expectation theory and projections in Hilbert spaces; parametric versus non-parametric geostatistics; Boolean, Gaussian, fractal, indicator, and annealing approaches to stochastic imaging; multiple point statistics inference and prediction; neural net geostatistics; Bayesian methods for data integration; techniques for upsampling hydrodynamic properties. May be repeated for credit. Prerequisites: 240, advanced calculus, C++/Fortran.
3-4 units, not given this year

EESS 300. Earth Sciences Seminar
(Crosslisted in each department in the School of Earth Sciences.) Required for incoming graduate students except coterms. Research questions, tools, and approaches of faculty members from all departments in the School of Earth Sciences. Goals are: to inform new graduate students about the school’s range of scientific interests and expertise; and introduce them to each other across departments and research groups. Two faculty members present work at each meeting. May be repeated for credit.
1 unit, Aut (Harris, J)

EESS 301. Topics in Environmental Earth System Science
Current topics, issues, and research related to interactions that link the oceans, atmosphere, land surfaces and freshwater systems. May be repeated for credit.
1 unit, Aut (Fendorf, S), Win (Staff), Spr (Staff)

EESS 322A. Seminar in Hydrogeology
Current topics. May be repeated for credit. Autumn Quarter has open enrollment. For Winter Quarter, consent of instructor is required.
1 unit, not given this year
EESS 322B. Seminar in Hydrogeology
Current topics. May be repeated for credit. Prerequisite: consent of instructor.
   1 unit, Win (Gorelick, S)

EESS 330. Advanced Topics in Hydrogeology
Topics: questioning classic explanations of physical processes; coupled physical, chemical, and biological processes affecting heat and solute transport. May be repeated for credit.
   1-2 units, Aut (Gorelick, S), Win (Gorelick, S), Spr (Gorelick, S)

EESS 342. Geostatistics
Classic results and current research. Topics based on interest and timeliness. May be repeated for credit.
   1-2 units, Aut (Boucher, A)

EESS 342B. Geostatistics
Classic results and current research. Topics based on interest and timeliness. May be repeated for credit.
   1-2 units, not given this year

EESS 342C. Geostatistics
Classic results and current research. Topics based on interest and timeliness. May be repeated for credit.
   1-2 units, not given this year

EESS 385. Practical Experience in the Geosciences
On-the-job training, that may include summer internship, in applied aspects of the geosciences, and technical, organizational, and communication dimensions. Meets USCIS requirements for F-1 curricular practical training. May be repeated for credit.
   1 unit, Aut (Staff), Win (Staff), Spr (Staff), Sum (Staff)

EESS 398. Current Topics in Ecosystem Modeling
   1-2 units, not given this year

EESS 400. Graduate Research
May be repeated for credit. Prerequisite: consent of instructor.
   1-15 units, Aut (Staff), Win (Staff), Spr (Staff), Sum (Staff)