EARTH SYSTEM SCIENCE

Courses offered by the Department of Earth System Science are listed under the subject code ESS on the Stanford Bulletin's ExploreCourses web site (https://explorecourses.stanford.edu/search?view=catalog&academicYear=&page=0&q=ESS&filter-departmentcode-ESS=on&filter-coursestatus-Active=on&filter-term-Summer=on).

On April 16, 2015, the Senate of the Academic Council approved the change of name for the department to become the Department of Earth System Science. Prior to April 16, the department was named the Department of Environmental Earth System Science.

Earth System Science studies the planet's oceans, lands, and atmosphere as an integrated system, with an emphasis on changes occurring during the current period of overwhelming human influence, the Anthropocene. Faculty and students within the department use the principles of biology, chemistry, and physics to study problems involving processes occurring at the Earth's surface, such as climate change and global nutrient cycles, providing a foundation for problem solving related to environmental sustainability and global environmental change.

Graduate Programs in Earth System Science

The University's basic requirements for the M.S. and Ph.D. degrees are discussed in the "Graduate Degrees (http://www.stanford.edu/dept/registrar/bulletin/4901.htm)" section of this bulletin. The Department of Earth System Science does not offer coterminal admission to the master's in Earth System Science.

Learning Objectives (Graduate)

The objectives of the doctoral program in Earth System Science 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 develop strong communication skills with the ability to teach and communicate effectively with the public.

The objectives of the master's program in Earth System Science is to continue a student's training in one of the earth science disciplines and to prepare students for a professional career or doctoral studies.

On April 16, 2015, the Senate of the Academic Council approved the Master of Science in Earth System Science. Students who matriculated into the Master of Science in Environmental Earth System Science have the option of changing the name of their degree to Earth System Science. Degree requirements remain the same.

Master of Science in Earth System Science

The University's requirements for M.S. degrees are outlined in the "Graduate Degrees (http://www.stanford.edu/dept/registrar/bulletin/4901.htm)" section of this bulletin.

Admission

For admission to graduate work in the department, the applicant must have taken the Aptitude Test (verbal, quantitative, and analytical writing assessment) of the Graduate Record Examination. In keeping with University policy, applicants whose first language is not English must submit TOEFL (Test of English as a Foreign Language) scores from a test taken within the last 18 months. Individuals who have completed a B.S. or two-year M.S. program in the U.S. or other English-speaking country are not required to submit TOEFL scores.

Unit Requirements

1. A minimum of 45 units of course work at the 100 level or above.
2. Half of the courses used to satisfy the 45-unit requirement must be intended primarily for graduate students, usually at the 200 level or above.
3. No more than 15 units of thesis research may be used to satisfy the 45-unit requirement.
4. Some students may be required to make up background deficiencies in addition to these basic requirements.
5. By the end of Winter Quarter of the first year in residence, a student must complete at least three courses taught by a minimum of two different department faculty members.

Course Work

		Units
Required Core Courses (Students are required to take three 2-unit courses during the first year):		
ESS 305	Climate Change: An Earth Systems Perspective	2
ESS 306	From Freshwater to Oceans to Land Systems: An Earth System Perspective to Global Challenges	2
ESS 307	Research Proposal Development and Delivery	2
Distribution Requirements (Students must take one class from each of the following three areas within the first or second year):		
Area A: Analysis of the Earth System (Select one course)		
ESS 214	Introduction to geostatistics and modeling of spatial uncertainty	3-4
GEOLSCI 240	Data science for geoscience	3
GEOPHYS 217	Numerical Methods in Engineering and Applied Sciences	3
CME 106	Introduction to Probability and Statistics for Engineers	4
CEE 362A	Uncertainty Quantification	3
STATS 200	Introduction to Statistical Inference	3
STATS 206	Applied Multivariate Analysis	3
STATS 207	Introduction to Time Series Analysis	3
STATS 216	Introduction to Statistical Learning	3
STATS 366	Modern Statistics for Modern Biology	3
Area B: Measurement of the Earth System (Select one course)		
ESS 210	Techniques in Environmental Microbiology	3
ESS 212	Measurements in Earth Systems	3-4
ESS 224	Remote Sensing of Hydrology	3
ESS 241	Remote Sensing of the Oceans	3-4
ESS 243	Molecular Geomicrobiology Laboratory	4
ESS 253S	Hopkins Microbiology Course	3-12
ESS 262	Remote Sensing of Land	4
Area C: Earth System Processes, Models, and Human-Environmental Interactions (Select one course)		
ESS 206	World Food Economy	4
ESS 220	Physical Hydrogeology	4
ESS 221	Contaminant Hydrogeology and Reactive Transport	3
ESS 223	Ecophysiology and Land Surface Processes	4
ESS 242	Antarctic Marine Geology and Geophysics	3
ESS 244	Marine Ecosystem Modeling	3
ESS 246A	Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation	3

ESS 246B	Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation	3
ESS 247	Tropical Meteorology	3-4
ESS 258	Geomicrobiology	3
ESS 270	Analyzing land use in a globalized world	3
ESS 360	Social Structure and Social Networks	5
Seminar Requirements		
Each quarter during the first academic year:		
ESS 301	Topics in Earth System Science	1

Teaching Assistantship

As a program requirement, advanced degree candidates in ESS complete TA-appointed (25%) quarters at a minimum of: 2 for Ph.D. students and 1 for master's students, to be completed over the course of study. In addition, additional TA quarters may be considered and/or required in consultation with the research adviser, depending on academic goals, funding availability, or the requirements of individual doctoral programs.

Advising

The department's graduate coordinator, in coordination with the departmental faculty, appoints an academic adviser prior to registration with appropriate consideration of the student's background, interests, and professional goals. In consultation with the adviser, the student plans a program of course work for the first year. The faculty adviser is charged with designing the curriculum in consultation with the student specific to the research topic.

Thesis

Each student must complete a thesis describing his or her research. Thesis research should begin during the first year of study at Stanford and should be completed before the end of the second year of residence. Early during the thesis research period, and after consultation with the student, the thesis adviser appoints a second reader for the thesis who must be approved by the graduate coordinator; the thesis adviser is the first reader. The two readers jointly determine whether the thesis is acceptable for the M.S. degree in the department.

Master of Science, Course Work Only Option for ESS Ph.D. Students

The course-work-only M.S. for ESS Ph.D. students requires 45 unduplicated units of which all 45 must be course work (non-research, non-independent study, non-thesis units). All required units must be in courses at the 100-level or above, 50 percent of those units must be in graduate-level courses (generally, at the 200-level or above). No units are awarded for course work completed elsewhere (i.e., not eligible to transfer-in units). All 45 units can be applied to the 135 unit requirement for the Ph.D. The remaining 90 units can consist of all research units

On April 16, 2015, the Senate of the Academic Council approved the Doctor of Philosophy in Earth System Science. Students who matriculated into the Doctor of Philosophy in Environmental Earth System Science have the option of changing the name of their degree to Earth System Science. Degree requirements remain the same.

Doctor of Philosophy in Earth System Science

The University's requirements for the Ph.D. degree are outlined in the "Graduate Degrees (http://www.stanford.edu/dept/registrar/bulletin/4901.htm)" section of this bulletin.

Admission

For admission to graduate work in the department, the applicant must have taken the Aptitude Test (verbal, quantitative, and analytical writing assessment) of the Graduate Record Examination. In keeping with University policy, applicants whose first language is not English must submit TOEFL (Test of English as a Foreign Language) scores from a test taken within the last 18 months. Individuals who have completed a B.S. or two-year M.S. program in the U.S. or other English-speaking country are not required to submit TOEFL scores.

Unit Requirements

1. A minimum of 135 units of graduate study at Stanford must be satisfactorily completed.
2. Required courses must be taken for a letter grade, if offered.
3. Ph.D. students registered for 10 units must pass at least 6 units per quarter. Students must maintain at least a 3.0 grade point average.
4. Ph.D. students must complete a minimum of four graduate level, letter-grade courses of at least 3 units each from four different faculty members on the Academic Council in the University.
5. By the end of Spring Quarter of their first year in residence, students must complete at least three graduate level courses taught by a minimum of two different ESS faculty members.

Course Work

		Units
Required Core Courses (Students are required to take three 2-unit courses during the first year):		
ESS 305	Climate Change: An Earth Systems Perspective	2
ESS 306	From Freshwater to Oceans to Land Systems: An Earth System Perspective to Global Challenges	2
ESS 307	Research Proposal Development and Delivery	2
Distribution Requirements (Students must take one class from each of the following three areas within the first or second year):		
Area A: Analysis of the Earth System (Select one course)		
ESS 214	Introduction to geostatistics and modeling of spatial uncertainty	3-4
GEOLSCI 240	Data science for geoscience	3
GEOPHYS 217	Numerical Methods in Engineering and Applied Sciences	3
CME 106	Introduction to Probability and Statistics for Engineers	4
CEE 362A	Uncertainty Quantification	3
STATS 200	Introduction to Statistical Inference	3
STATS 206	Applied Multivariate Analysis	3
STATS 207	Introduction to Time Series Analysis	3
STATS 216	Introduction to Statistical Learning	3
STATS 366	Modern Statistics for Modern Biology	3
Area B: Measurement of the Earth System (Select one course)		
ESS 210	Techniques in Environmental Microbiology	3
ESS 212	Measurements in Earth Systems	3-4
ESS 224	Remote Sensing of Hydrology	3
ESS 241	Remote Sensing of the Oceans	3-4
ESS 243	Molecular Geomicrobiology Laboratory	3-4
ESS 253S	Hopkins Microbiology Course	3-12
ESS 262	Remote Sensing of Land	4
Area C: Earth System Processes, Models, and Human-Environmental Interactions (Select one course)		
ESS 206	World Food Economy	4
ESS 220	Physical Hydrogeology	4
ESS 221	Contaminant Hydrogeology and Reactive Transport	3

ESS 223	Ecophysiology and Land Surface Processes	4
ESS 242	Antarctic Marine Geology and Geophysics	3
ESS 244	Marine Ecosystem Modeling	3
ESS 246A	Atmosphere, Ocean, and Climate Dynamics: The Atmospheric Circulation	3
ESS 246B	Atmosphere, Ocean, and Climate Dynamics: the Ocean Circulation	3
ESS 247	Tropical Meteorology	3-4
ESS 258	Geomicrobiology	3
ESS 270	Analyzing land use in a globalized world	3
ESS 360	Social Structure and Social Networks	5
Seminar Requirements		
Each quarter during the first academic year:		
ESS 301	Topics in Earth System Science	1

Teaching Assistantship

As a program requirement, advanced degree candidates in ESS complete TA-appointed (25%) quarters at a minimum of: 2 for Ph.D. students and 1 for master's students, to be completed over the course of study. In addition, additional TA quarters may be considered and/or required in consultation with the research advisor, depending on academic goals, funding availability, or the requirements of individual doctoral programs.

Annual Review

Each year, the department evaluates students to assess progress to degree, identify areas of strength, provide helpful resources, and note potential issues or areas of concern. This annual review includes a record of accomplishments presented by the student, written evaluations by the faculty adviser of the student's progress, and committee feedback on the academic and research progress of the student. The student should have no 'I' grades in core courses, must maintain at least a 3.0 grade-point average, and show evidence of productive and sustained research progress, with no conflict of interest or conflict of commitment.

Possible outcomes of the annual review include: (1) continuation of the student in good standing, and (2) placing the student on probation, with specific written guidelines of the period of probation and the necessary steps for reinstatement to good standing.

Annual reviews are required for all Ph.D. students, including first-year Ph.D. students. In the first year, the annual review is conducted between the student and the Ph.D. adviser(s) (prior to forming a doctoral committee). After the first year, the annual review must be conducted between the student and the student's doctoral committee. In all years, the written annual review form must be completed and signed by both the student and the adviser.

In the year in which students are undertaking their candidacy exam (research qualifying exam), that exam serves as the annual review. In addition, any student who has scheduled the dissertation defense and petitioned to graduate in Axess may elect not to hold an additional annual review meeting. Annual reviews that are not the qualifying exam or dissertation defense should take place in the Autumn or Winter Quarter (with the exception of first-year students, who may hold their annual review meeting with their adviser(s) in Spring Quarter).

Candidacy and Qualification Exam

Admission to a doctoral degree program is preliminary to, and distinct from, admission to candidacy. Admission to candidacy for the doctoral degree is a judgment by the faculty in the department or school of the student's potential to successfully complete the requirements of the degree program. Candidacy is valid for five calendar years (through the end of the quarter in which candidacy expires), unless terminated by the department (for example, for unsatisfactory progress). University policy requires completion of the department qualifying procedures and application for candidacy by the end of the second year in the Ph.D. program. Therefore, it is strongly advised that the qualifying exam be taken during the fith (non-Summer) quarter so that the student may retake the exam in the case of inadequate performance and still advance to candidacy by the end of the sixth (non-Summer) quarter.

Students must present a draft proposal to their adviser in a timely fashion, and take account of the adviser's comments and require revisions before preparing a final draft. The student submits a copy of the final draft of the research proposal to each member of the examining committee at least two weeks before the scheduled date of the examination.

The qualifying exam is an oral exam based on the candidate's written research proposal. The exam is a test of the student's ability to recognize, evaluate, and plan a significant research project and his/her mastery of fields essential to the completion of research. The research proposal must provide a concise review of the background literature, and must discuss the proposed problem, its importance, and the methods to be applied to its examination. The methods should be made clear. The proposal must contain a timetable and, if appropriate, the student should discuss such matters as funding, field logistics, laboratory scheduling, and availability of equipment. The proposal must be well thought out, carefully written and edited, and finished with appropriate references and illustrations. It must not exceed 15 double-spaced pages in length, exclusive of figures and bibliography. The qualifying exam is oral and consists of three parts:

1. A presentation of the proposed research (no more than 30 minutes duration);
2. An examination of the candidate on the merits of the proposal, touching on but not limited to the aspects listed in the proposal; and
3. An examination of any subject matter judged by committee members to be relevant to the student's ability to carry out the proposed research.

It is recognized that, in practice, parts 1# 3 may not be entirely separate and distinct. The entire examination lasts no less than 2 hours and no more than 3 hours; the examination under part 3 is at least one hour. No part of examination is public.

Doctoral Dissertation and Oral Defense

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.

Graduate Advising Expectations

The Department of Earth System Science is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the adviser and the advisee. As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

Faculty advisers guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

Graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

For a statement of University policy on graduate advising, see the "Graduate Advising (http://exploredegrees.stanford.edu/graduatedegrees/#advisingandcredentialstext)" section of this bulletin.

Chair: Robert Jackson

Professors: Kevin Arrigo, Noah Diffenbaugh[3], Robert Dunbar, Scott Fendorf, Christopher Field[1,3], Christopher Francis, Steven Gorelick, Robert Jackson[2,3], Eric Lambin[3], David Lobell[3,4], Pamela Matson, Rosamond Naylor [3,4]

Associate Professors: Karen Casciotti, James Holland Jones, Kate Maher, Leif Thomas

Assistant Professors: Marshall Burke [4], Anne Dekas, Alexandra Konings, Morgan O'Neill, Aditi Sheshadri, Paula Welander

Courtesy Professors: Gregory Asner, Ken Caldeira, Anna Michalak, Peter Vitousek

Visiting Professors:

[1]Joint appointment with Biology

[2]Joint appointment with the Precourt Institute for Energy

[3] Joint appointment with the Woods Institute for the Environment

[4]Joint appointment with the Freeman Spogli Institute for International Studies