EARTH SYSTEM SCIENCE PROGRAM

PROFESSORS

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ASSOCIATE PROFESSORS

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GENERAL INFORMATION: Earth System Sciences Graduate and Doctorate Programs address the growing national, regional and global demand for trained professionals in Earth System Sciences and applications. The degree emphasizes a research-oriented, global systems approach to study the atmosphere, hydrosphere, and lithosphere, including their interrelationships and interactions with the biosphere. Emphasis is on the observation and quantitative analysis of Earth systems which human inflicted problems. Students completing the program will be qualified to pursue careers that require knowledge of the basics of Earth system science and the requisite tools.

The need for the programs exists because human after the industrial revolution modified the global environment faster than they understood the consequences of their changes. The major theme of the program is therefore sustainability, defined as meeting human needs and values while preserving and improving the planets life-support systems.

Graduates of Faculties of Engineering, Social Sciences and Science, those working on this subject in Ministries of Energy and Natural Resources, Environment & Forestry, General Directorate of Meteorology and Policy Making Institutions can apply for graduate study in ESS Department.

Graduates of this program will have a strong background in the theory and application of Earth Systems Science. In this respect, to develop sustainable use of natural resources, technologies, and implement policies becomes crucial, both in a national and global scale. They will be well prepared for either graduate studies or jobs in the areas environmental change (e.g. climate change) and protection, natural resource management and policy.

ADMISSION REQUIREMENTS AND PREREQUISITES: Earth System Science graduate and doctorate program s welcome graduates, i.e. B.Sc. or M. Sc. holders from the departments of Faculty of Art and Sciences, Faculty of Engineering, Faculty of Architecture, Faculty of Economic and Administrative Sciences, and Graduate Schools (GSANS, MASC, IS, IAM). All applicants concerning admission to this program should be made through the Graduate School of Natural and Applied Sciences of the Middle East Technical University. Students who wish to enroll for graduate programme in the ESS must be qualified for graduate standing in METU. Proficiency in English at the minimum level of a TOEFL score of 79 or a score in EPE of 65 is required. Applicants are evaluated and accepted to the program based on their CGPA and Graduate Admission Examination (ALES). Since the ESS Graduate Program is highly interdisciplinary, requirements for admission can be flexible and each application can be judged on its own merits and the applicant's background.

TRACKS: Earth System Science (ESS) will provide an integrated approach to analyze earth system science. Courses offered in the Program examine interactions among components of the Earth Systems under three tracks.

Tracks in ESS Program

Track	Area Name	Program Type
I	Earth System Science	MS and PhD
II	Earth System Modeling	MS and PhD
III	Energy, Environmental Economics and Policy	MS, PhD and MS without thesis

GRADUATE CURRICULUM

M.S. with thesis in Earth System Science

ESS	500	M.S. Thesis	NC
ESS	501	The Earth System	(3-0)3
ESS	502	Earth System Science: Economics and Policy	(3-0)3
ESS	590	Seminar	NC

2 restricted elective courses from Group 1
3 elective courses

Total minimum credit: 21
Number of Courses with credit (min): 7

M.S. without thesis in Earth System Science

ESS	501	The Earth System	(3-0)3
ESS	502	Earth System Science: Economics and Policy	(3-0)3
ESS	590	Seminar	NC
ESS	599	Term Project	NC

2 restricted elective courses from Group 1
2 restricted elective courses from Group 2
4 elective courses

Total minimum credit: 30
Number of Courses with credit (min): 10

Ph.D. in Earth System Science

If admitted by M.S. degree in ESS

ESS	600	Ph.D. Thesis	NC
ESS	690	Seminar	NC

2 restricted elective courses from Group 2
5 elective courses

Total minimum credit: 21
Number of Courses with credit (min): 7

Ph.D. in Earth System Science *

If admitted by M.S. degree from other programs

ESS	600	Ph.D. Thesis	NC
ESS	690	Seminar	NC
2 restricted elective courses from Group 1			
2 restricted elective courses from Group 2			
3 elective courses			

Total minimum credit: 21
Number of Courses with credit (min): 7
* In deficiency program, students must take ESS 501 and ESS 502

Ph.D. after B.S. in Earth System Science

ESS	501	The Earth System	(3-0)3
ESS	502	Earth System Science: Economics and Policy	(3-0)3
ESS	590	Seminar	NC
ESS	600	Ph.D. Thesis	NC
ESS	690	Seminar	NC

2 restricted elective courses from Group 1 (i.e. ESS 503/504/505/506)
2 restricted elective courses from Group 2 (i.e. PHIL 588, IR 570, ESS 507/508)
8 elective courses
Total minimum credit: 42
Number of Courses with credit (min): 14

GRADUATE COURSES

ESS	500	M.S. Thesis	NC
ESS	501	The Earth System	(3-0)3
ESS	502	Earth System Science: Economics and Policy	(3-0)3
ESS	503	Sustainable Development	(3-0)3
ESS	504	Environment, Society and Technology	(3-0)3
ESS	505	Global Biogeochemistry	(3-0)3
ESS	506	Nature and Human Use	(3-0)3
ESS	507	Climate Change and Modelling	(3-0)3
ESS	508	Environmental Economics	(3-0)3
ESS	509	Energy Policy and Finance	(3-0)3
ESS	590	Seminar I in ESS	(0-2)NC
ESS	599	Term Project	(0-4)NC
ESS	600	Ph.D. Thesis	NC
ESS	690	Seminar II in ESS	(0-2)NC
ESS	7XX	Special Topics in Earth System Science	(3-0)3
ESS	8XX	Special Studies	(4-2)NC
ESS	9XX	Advanced Studies	(4-2)NC

RESTRICTED ELECTIVE COURSES

Group 1: Two courses must be selected from:

PHIL	588	Environmental Ethics
IR	570	Global Environmental Issues
ESS	507	Climate Change and Modelling
ESS	508	Environmental Economics

Group 2: Two courses must be selected from:

ESS	503	Sustainable Development
ESS	504	Environment, Society and Technology
ESS	505	Global Biogeochemistry
ESS	506	Nature and Human Use

ELECTIVE COURSES

Track 1: Earth System Science

AEE	551	Introduction to Space Sciences
CHEM 589/ENVE 513		Atmospheric Chemistry / Topics in Atmospheric Chemistry
MASC	512	Chemical Oceanography
MASC	530	Int. To Physical Oceanography
MASC	571	Marine Ecology
MASC	583	Marine Geology
GEOE	506	Advanced Photogeology
GEOE	515	Advanced Geochemistry
GEOE	545	Applied Sedimentology
GEOE	550	Applied Geophysics
GEOE	568	Paleoclimatology

BIO	571	Advanced Ecology
BIO	574	Major Concepts in Ecology
BIO	587	Plant Biodiversity and conservation
BIO	588	Biodiversity and Habitat Conservation
BIO	714	Freshwater Ecology
BIO	744	Paleoecology
CE 599/CE 530		Groundwater Hydraulics/ Modeling of Hydrology
CE	5701	Hydroclimatology
CE	5603	Seismic Hazard Assesments
ENVE	538	Advanced Environmental Chemistry
PHYS	573	Physics of Solar Energy

Track 2: Earth System Modeling

AEE 541 / ES 572 / ES 554 / ES 571
Advanced Computational Fluid Dynamics/Advanced Fluid Mechanics/Nonlinear Dynamics/ Basic Principles of Fluid Mechanics

GGIT 562 / GEOE 559 / CE 761 / GEOE 555 / GGIT 560 / GGIT 538
Integration of Remote Sensing and GIS/GIS Models in Natural Hazard Assessment/Marine Hazards and Tsunami /Principles and Appl. of Imaging Radar Systems /Principles of Remote Sensing/Spatial Data Analysis

ES 508 / GEOE 517 / CHE 551 / CE 515 / ES 516
Statistical Methods for Eng./Adv. Geostatistics/Applied Data Analysis Techniques/Adjustment of Observations/Spectral Methods

CE 530 / CE 599 / GEOE 616 / GEOE 614
Modelling in Hydrology/Ground Water Hydaulics /Geochemistry of Nat. Waters /Groundwater systems Plan and Management

CE 5601 / GEOE 544
Geotechnical Earthquake Eng./ Stability of Soil Slopes in Eng. Practice

ENVE 502 / GEOE 567
Modeling Soil and Ground Water Pollution/Groundwater Contamination

Track 3: Energy, Environmental Economics and Policy

ESS	509	Energy Policies and Finance
GEOE 530/ PETE 519		Economics of Energy Resources / World Energy Sources
PHYS	573	Physics of Solar Energy
ECON	608	Computable General Equilibrium Models
BA	650	Applied Regression Analyses
CP	550	Solar Energy and Urban Planning
GGIT	535	Information Systems for Natural Resource Management
BIO	707	Societal Dependence on Natural Ecosystems
ENVE	707	Energy and the Environment
IR	580	Governance in Trans-boundary Water Systems
IR	669	Law of the Marine Environment,

DESCRIPTION OF COURSES

ESS 500 M.S. Thesis NC
A program of research leading to the M.S. degree is decided between the student and a faculty member. Students register to this course at all semesters starting from the beginning of their second semester while the research program or write-up of thesis is in progress.

ESS 501 The Earth System (3-0)3
Near Earth Space (NES): Electromagnetic and charge output of the Sun; radiation, plasma, neutral atmosphere and magnetic environment; the atmosphere, atmospheric dynamics and circulation patterns, atmospheric chemistry. Geosphere: Principals of geological processes, The Earth's materials, deposition in the deep oceans, lakes and rivers, geologic time scales. Hydrosphere: Fresh water over and in soil, ocean water and hydrological cycle, ocean systems, the ocean's role in the global geochemical and biogeochemical cycling and physical/climate systems, freshwater and marine ecosystems. Biosphere: Evolution of biological diversity, terrestrial and aquatic and marine ecosystems, GAIA, Geographic ecology, global ecology, biological feedback mechanisms at global scale. Climate Change-introduction: Introduction to climate variability and climate change. Future prospects for the Earth system.

ESS 502 Earth System Science: Economics and Policy (3-0)3
Institutional framework and issues of climate change; international context and treaties; economic concepts relevant to climate and environmental change; policy issues and options for mitigating the impact of climate change; methods of policy analysis and evolution including modeling fundamentals; model types and modeling issues.

ESS 503 Sustainable Development (3-0)3
To review core concepts and history of sustainable development; to introduce students to innovative frameworks to sustainable development, including institutional analysis, common-pool resource management, and the often overlooked cultural, and psychological underpinnings of environmental decision–making; to examine policy responses to environmental problems caused by economic development; to analyze social case studies and examples through the frameworks presented; to provide a forum for graduate students to present their own research interests and examples regarding sustainable development.

ESS 504 Environment, Society and Technology (3-0)3
The identification, investigation and evaluation of how environment, energy and technology are inter-related and how these interactions influence societal policy formulation, implementation and evaluation at the local, regional, national, international in the context of industrial and organizational levels.

ESS 505 Global Biogeochemistry (3-0)3
The origin and history of life on Earth, life and evolution, production and fate of organic material, major biogeochemical cycles (C, N, P, O, and S) and their interactions with physical, chemical and biological components of terrestrial and aquatic systems, links between local and global cycles, biogeochemical transformations and microbial loops, aerobic and anaerobic processes, climatic forcing of biogeochemical processes, anthropogenic environmental change mediated through both perturbation of biogeochemical cycles (eutrophication, ocean carbon sequestration) and through the introduction of contaminants (toxic organic compounds, heavy metals, trace elements), reconstructing the history of environmental change using chemical markers preserved in sedimentary or biological archives.

ESS 506 Nature and Human Use (3-0)3
Understanding of the natural environment and the environmental problems that the world faces. fundamental ecological principles, human population dynamics, biodiversity, natural resources and their use, human interaction with the environment, and personal and civic responsibility, anthropogenic changes on earth that are inflected by human population rise, environmental awareness as a basis for policy making and ethical decisions.

ESS 507 Climate Change and Modeling (3-0)3
Climate: Introduction to climate, the science of climate, elements and control of weather and climate, the nature of the atmosphere, role of oceans, the dynamics of the climate system, world pattern of climate. **Climate variability:** Time scales of climatic variations, long-term climate averages, annual climate variations, Earth's evolution and paleo-climatic changes. **Climate Change:** the Greenhouse gases and global warming,, Human activities and the climate change, sensitivity to external forcing, the cryosphere and records of environmental changes, ocean impacts and feedbacks, oceans and CO2 sequestration, **Climate modeling:** Types of data, Basic laws of physics for the models, systems of differential equations,

coupling atmosphere-ocean and land surface-sea icesystem, physical climate modeling, and accuracy of the models.

ESS 508 Environmental Economics (3-0)3
Consumption, production and cost. Competitive markets and welfare. Equilibrium and efficiency under different market structures. Market failure and the Coase theorem. Cost benefits analysis in imperfect markets. Natural and renewable resource economics. Policy alternatives to address environmental issues.

ESS 509 Energy Policy and Finance (3-0)3
Energy markets, game theory and strategic interaction, imperfections and regulation. World energy markets as alternative investment areas, price movements, international trade and finance, macroeconomics impacts of energy price shocks. Renewable energy policy, evaluating energy projects and energy project financing policy appraisal.

ESS 590 Seminar I in ESS (0-2)NC
Presentations of topics of general Program interest, current research activities and recent developments in the related fields by graduate students, staff members and invited speakers. M.Sc. students must register for this course at least once during their M.Sc., and M.Sc. students prepare a seminar directly related to their ongoing thesis research as part of the Earth System Science Master Program.

ESS 599 Term Project (0-4)NC
Project carried out under the supervision of a faculty member in a specific area of ESS. A written report is expected from students about their work.

ESS 600 Ph.D. Thesis NC
Program of research leading to Ph.D. degree arranged between student and a faculty member. Students register to this course in all semesters starting from the beginning of their second semester while the research program or write-up of thesis is in progress.

ESS 690 Seminar II in ESS (0-2)NC
Presentations of topics of general Program interest, current research activities and recent developments in the related fields by graduate students, staff members and invited speakers. Ph.D. and Ph. D. on B.S. students must register for this course
at least once during their Ph.D. and Ph. D. on B.S. Students prepare a seminar directly related to their ongoing thesis research as part of the Earth System Science Doctorate Program.

ESS 7XX Special Topics in Earth System Science (3-0)3
Courses not listed in the catalogue are given as Special Topics courses. Contents vary from year to year according to interest of students and instructor in charge. Courses include various earth system topics.

ESS 8XX Special Studies (4-2)NC
M.Sc. Students choose and study a topic under the guidance of a faculty member normally his/her advisor.

ESS 9XX Advanced Studies (4-2)NC
PhD Students choose and study a topic under the guidance of a faculty member normally his/her advisor.