

EARTH SCIENCES

Departmental Student Learning Outcomes

Earth Science graduates exhibit knowledge and understanding of the component of the Earth system specific to their discipline so that they are prepared to embark on their careers and work effectively to address complex issues.

Earth Science graduates can employ evidenced-based scientific reasoning to critically think about problems in the Earth sciences. Students will engage in observation, inquiry, analysis, and synthesis to expand their knowledge and understanding of the Earth system in the courses and/or in student research.

Earth Science graduates demonstrate skill in the use of tools and the application of technologies appropriate to their discipline. Students will be able to evaluate the scientific problem to determine the appropriate tool and/or technology necessary to solve the problem and then employ that tool and/or technology effectively.

Earth Science graduates can effectively communicate their knowledge and understanding in both oral and written formats to diverse audiences.

Program Overviews & Workforce Projections

The Earth Sciences span the disciplines of climate, energy, environmental hazards, mineral and water resources, tectonics, and weather. The need for energy, environmental protection, and responsible land and water resource management is projected to spur demand for geoscientists in the future (Bureau of Labor Statistics 2020). Earth Sciences courses are rigorous and comprehensive utilizing the most current technology so that students not only develop but also apply knowledge of their discipline to solve complex problems. Our students engage in research of critical importance such as identifying key processes in the forecasting of snowfall or determining how fluids flow through fractured and porous rock units. Graduates from the Earth Sciences curriculum find satisfying careers in the atmospheric sciences, emergency management, and the environmental geo- and ocean sciences.

Our bachelor's degrees are designed to prepare students for the professional workforce or graduate education with qualifications and skills that will ensure success. The meteorology curriculum conforms to the American Meteorological Society's (AMS) guidelines for a B.S. in atmospheric science/meteorology, and the GS-1340 civil service requirements for government employment (e.g., National Weather Service, NOAA). The BS EEOS environmental geology option exceeds the academic requirements for professional licensure and prepares every student for success through extensive opportunities to apply their skills in the field. The BS EEOS program has ocean/bay access at the Chincoteague Bay Field Station (CBFS), where students have opportunities for hands-on, feet-wet experiences, on shore and onboard research vessels. Academic minors in areas where the workforce is strong or emerging, such as data science, emergency management, environmental policy, geospatial sciences, mathematics, broadcast communication, government and political affairs, and heliophysics and space weather, are encouraged but not required.

Millersville University is a senior partner of the CBFS, institutional member of the American Geophysical Union (AGU), American Geosciences Institute (AGI), American Meteorological Society (AMS), International Association of Emergency Managers (IAEM), National Weather Association (NWA), University Corporation for Atmospheric

Research (UCAR), and an educational partner of the Weather Risk Management Association (WRMA). The University is a participant in the National Weather Service (NWS) StormReady® program and the Mid-Atlantic Regional Association Coastal Observing System, and the AMS Student Chapter is a member of the Weather-Ready Nation (WRN). For more information, see www.millersville.edu/esci (<https://www.millersville.edu/esci/>)

the programs

- Earth Science, B.S.E. (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/earth-science-bse/>)
- Earth Sciences Minor (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/earth-sciences-minor/>)
- Emergency Management, B.S. (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/emergency-management-bs/>)
- Environmental Earth & Ocean Science, B.S. - Environmental Earth Sciences Option (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/environmental-earth-ocean-science-bs-environmental-earth-sciences-option/>)
- Environmental Earth & Ocean Science, B.S. - Environmental Geology Option (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/environmental-earth-ocean-science-bs-environmental-geology-option/>)
- Environmental Earth & Ocean Science, B.S. - Environmental Ocean Sciences Option (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/environmental-earth-ocean-science-bs-environmental-ocean-sciences-option/>)
- Environmental Hazards and Emergency Management Minor (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/environmental-hazards-emergency-management-minor/>)
- Geology Minor (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/geology-minor/>)
- Heliophysics and Space Weather Minor (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/heliophysics-space-weather-minor/>)
- Hydrology Minor (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/hydrology-minor/>)
- Meteorology Minor (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/meteorology-minor/>)
- Meteorology, B.S. (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/meteorology-bs/>)
- Oceanography Minor (<https://catalog.millersville.edu/undergraduate/college-science-technology/earth-sciences/oceanography-minor/>)

the faculty

Blumberg, William; Assistant Professor
College of Science and Technology
B.S., University of Oklahoma, 2011; M.S., Ibid., 2013; Ph.D., Ibid., 2018

Casas, Eleanor; Assistant Professor
College of Science and Technology
B.S., Valparaiso University, 2015; M.S., Colorado State University, 2018; Ph.D., Ibid., 2022

Earman, Samuel; Associate Professor
College of Science and Technology

B.A., Macalester College, 1989; M.S., University of Nevada, 1996; Ph.D., New Mexico Institute of Mining and Technology, 2004

Hagelgans, Duane; Professor

College of Science and Technology

B.S., Millersville University, 1998; J.D., Widener University School of Law, 2003

Kumar, Ajoy; Professor

College of Science and Technology

B.S., University of Madras (India), 1985; M.S., Ibid., 1987; Ph.D., Old Dominion University, 1996

Marquez, L; Professor

College of Science and Technology

B.A., DePauw University, 1991; M.S., Northwestern University, 1994, Ph.D., Ibid., 1998

Sikora, Todd; Professor

College of Science and Technology

B.S., The Pennsylvania State University; M.S., Ibid., 1992; Ph.D., Ibid., 1996

Vaillancourt, Robert; Professor

College of Science and Technology

Ph.D., University of Rhode Island, 1999

Walsh, Talor; Associate Professor

College of Science and Technology

B.A., Oberlin College, 2007; M.S., University of Rochester, 2012; Ph.D., Ibid., 2015

Yalda, Sepideh; Professor

College of Science and Technology

B.S., Saint Louis University, 1991; M.S., Ibid., 1993; Ph.D., Ibid., 1997

the courses

EHEM 201: 3 s.h.

Introduction to Emergency Management (G3)

An introduction into all aspects of emergency management from the origins through the civil defense era to the present day with a look towards the future of the global aspect of emergency management. Students will learn the basics of emergency management, how to function as an effective emergency manager and how to manage an emergency management agency. Prereq: ENGL 110.

EHEM 201H: 3 s.h.

H:Intro to Emergency Mgmt (G3)

EHEM 205: 3 s.h.

Natural Hazards Risk Assessment and Mitigation

An exploration of risk assessment methodologies for natural disasters, review of natural hazard mitigation and its role in disaster management; analysis of past and current government and private sector programs; and an examination of new approaches. Natural hazard mitigation implementation approaches including those in the form of community-wide programs and to relate the hazard mitigation processes to disaster planning.

EHEM 205H: 3 s.h.

Hon: Hazards Assmt & Mitigatn

EHEM 300: 3-12 s.h.

Co-Op Ed Experience in EHEM

Co-Op Ed Experience in EHEM

EHEM 305: 3 s.h.

Disaster Management & Community Risk Reduction (G3)

Study of current trends of building disaster resilient and disaster resistant communities to prevent the size of the devastation from these disasters. An examination into prevalent legislation that controls and shapes both building construction and land use planning, technological advances for building a disaster resistant community and legal issues of community planning. Prereq: EHEM 201

EHEM 305H: 3 s.h.

Hon: Dis Mgmt & Comm Risk Redu (G3)

EHEM 309: 3 s.h.

Disaster Response & Recovery

An in-depth treatment of emergency management practices as it applies to local, state, tribal, territorial, and federal disaster response in the context of short-term and long-term community recovery. The disaster response and recovery efforts will be addressed with a foundation of statutory requirements, key concepts, core principles, roles and responsibilities of leadership ranging from the individual to the Federal government and across the public, private, and the non-profit sectors.

EHEM 309H: 3 s.h.

Hon: Disaster Resp/Recovery

EHEM 315: 3 s.h.

Business Continuity and Continuity of Operations

Critical dependence of private and public organizations on disaster vulnerable technologies and operations as a result of natural and man-made disasters. Students will have the opportunity to review the contemporary plan development strategies and methodologies and to produce working plans that provide preventive measures to minimize the impact of all disasters and provide an organized response to ensure continuity of operations. Concepts of business continuity management system consisting of risk identification and mitigation, business impact analysis, development of continuity strategies, training and awareness, plan creation, maintenance and testing will be emphasized.

EHEM 316: 3 s.h.

Intro to Terrorism, WMD and Homeland Security (G3)

An introduction into all aspects of terrorism, weapons of mass destruction and homeland security in our modern world. A study of the overall history of terrorism, legislation that oversees emergency management, and various methods for combating terrorism. How to manage an emergency management agency through modern age terrorism threats. Prereq: EHEM 201.

EHEM 319: 3 s.h.

Emergency Management Planning

Provides students with an in-depth analysis of planning methodologies and constructs as well as pitfalls and limiting factors in the development and execution of emergency management plans at the strategic, operational and tactical levels. Pre-requisite EHEM 201

EHEM 329: 3 s.h.

Special Topics in Emergency Management

In-depth investigation and development of one or more topics of current or emerging not addressed as part of the existing curriculum. Prereq: EHEM 201 or EHEM 205

EHEM 393: 3 s.h.**Field Experience Practicum**

A capstone experience in which emergency-management knowledge and skills are applied and integrated within a field experience. Those already working within an emergency-management-related career can use their current position as the basis for completing a project applicable to enhancing their current skills and applying best practices. For BS Emergency Management majors and Environmental Hazards and Emergency management minors only. Senior level and 18 credits in EHEM courses required. Permission of instructor required to enroll.

EHEM 400: 3-12 s.h.**Co-Op Ed Experience in EHEM**

Co-Op Ed Experience in EHEM

EHEM 489: 1-3 s.h.

Hnrs:

EHEM 498: 1-4 s.h.

Ind Stdy:

Ind Stdy:

EHEM 499: 1-3 s.h.

Hnrs Thesis:

ESCI 101: 3 s.h.**Earth Systems & Natural Hazards (G2)**

The scientific understanding of Earth systems as the causes of natural disasters, such as earthquakes, volcanoes, landslides, hurricanes, tornadoes, floods and tsunamis. 3 hrs. lec. Does not count toward Meteorology major.

ESCI 101H: 3 s.h.

Hon: Earth Sys/Nat Hzrds (G2)

ESCI 102: 3 s.h.**Origin and Evoltn of the Earth (G2)**

The origin and evolutionary development of the universe, solar system and planet Earth. Geophysical behavior of the solid earth, including volcanism, mountain building and other manifestations of the Earth's dynamic interior. Does not count toward Meteorology major.

ESCI 104: 3 s.h.**The World Ocean (G2)**

A broad overview of the biological, chemical, geological and physical characteristics of the ocean, the importance of the oceans to mankind and the environment. Does not count toward Meteorology major.

ESCI 104H: 3 s.h.

Hnrs:The World Ocean (G2)

ESCI 105: 1 s.h.**World Ocean Laboratory (G2)**

Methods and techniques used in the marine sciences, including introduction to navigation, plotting and evaluation of data pertaining to salinity, temperature, dissolved oxygen, primary productivity and current velocity. 2 hrs. lab. Mandatory coreq: ESCI 104. ESCI 104/105 together constitute a single laboratory course in earth sciences for purposes of the general education curriculum. Does not count toward Meteorology major.

ESCI 107: 3 s.h.**The Atmosphere (G2)**

Origin and evolution of the atmosphere; solar and terrestrial radiation; horizontal and vertical structure of the atmosphere; temperature, pressure and water in the air; vertical motion; cloud formation and cloud type; circulation systems, severe weather, climate and climate change. Does not count toward Meteorology major. Credit may not be received for ESCI 107 if ESCI 109 is taken, these are equivalent courses and will be treated as repeated course credit.

ESCI 107H: 3 s.h.

Hon: The Atmosphere (G2)

ESCI 109: 4 s.h.**Atmosphere with Lab (G2)**

Origin and evolution of the atmosphere; solar and terrestrial radiation; horizontal and vertical structure of the atmosphere; temperature, pressure and water in the air; vertical motion; cloud formation and cloud type; circulation systems, severe weather, climate and climate change. Does not count toward Meteorology major. Credit may not be received for ESCI 109 if ESCI 107 is taken, these are equivalent courses and will be treated as repeated course credit.

ESCI 120: 3 s.h.**Environmental Geology (G2)**

Exploration of Earth systems and their relation to society, with focus on natural hazards and natural resources. Does not count toward Meteorology major.

ESCI 121: 1 s.h.**Environmental Geology Lab (G2)**

Laboratory exploration of Earth system impacts on society, human influences on Earth. Mandatory coreq. ESCI 120. ESCI 120/121 taken concurrently constitute a single laboratory course in earth science for purpose of the general education curriculum. Does not count toward Meteorology major.

ESCI 121H: 1 s.h.

Hon: Environ Geology Lab (G2)

ESCI 179: 3 s.h.**Experimental**

Experimental

ESCI 202: 3 s.h.**The Earth in Space (G2)**

A scientific experience directed toward an understanding of the dynamic earth, its origin and evolution and its place in the universe. Physical concepts from classical and modern physics, astronomy, cosmology, and the earth and atmospheric sciences, couched in the language of algebra and supported by observation, experiment and theory. Prereq: MATH 101 with C- or higher or MPT 151 with C- or higher, or MATH 151 or MATH 161 or MATH 163 or MATH 204 (151, 161, 163, 204, grade of C- or higher) or permission of instructor.

ESCI 221: 4 s.h.**Physical Geology (G2)**

The nature and distribution of materials of the solid Earth - the dynamic processes by which they are formed and modified and the character of resulting geologic structures. 3 hrs. lec., 2 hrs. lab. Offered in fall, spring.

ESCI 221H: 4 s.h.

Hnrs:Physical Geology (G2)

ESCI 222: 4 s.h.**Historical Geology (G2, W)**

Methods of interpreting the geologic rock record, chronologic study of earth history and study of fossils as records of ancient life. Emphasis on the history of North America. 3 hrs. lec., 2 hrs. lab, field trips required. Prereq: C- or higher in ESCI 221.

ESCI 222H: 4 s.h.**H:Historical Geology (G2)****ESCI 225: 3 s.h.****Geomorphology**

Processes of landscape development in theory and in the context of the regional geomorphology of North America. 3 hrs. lec. Offered in fall of odd years. Prereq: C- or higher in ESCI 221.

ESCI 226: 3 s.h.**Geology of Earth and Energy Resources (G2)**

Investigation of the geologic origin of Earth resources important to society (including energy resources, metals, industrial materials and evaporites); methods of resource evaluation, extraction and processing; and environmental impacts of resource extraction/use. 3 hrs. lec.

ESCI 241: 4 s.h.**Meteorology (G2)**

Atmospheric structure and motions; physics of weather processes; weather and motion systems. 3 hrs. lec., 2 hrs. lab. Coreq or Prereq: C- or higher in MATH 161 or 163H.

ESCI 245: 3 s.h.**Environmental Meteorology (G2)**

Practical meteorological problems in air pollution, atmospheric experimentation and other aspects of the human environment. Instrumentation and data analysis methods in applied meteorology. 2 hrs. lec., 2 hrs. lab. Offered in spring and online in summer. Prereq: C- or higher in MATH 110 or 160 or 161 or 163H.

ESCI 261: 4 s.h.**Introduction to Oceanography (G2)**

A survey of the field of oceanography including modern topics in the four subdisciplines of physical, geological, chemical, and biological oceanography. 3 hrs. lec., 2 hrs. lab. Overnight field trip may be required at discretion of professor. Prereq: C- or higher in MATH 101 (college algebra) or math placement into MATH 160 or higher.

ESCI 267: 3 s.h.**Field Methods in Oceanography**

Work on board small research vessels in the dynamic marine environment; use and application of standard oceanographic instruments and sampling devices; opportunities for independent research. 1 hr. lec., 4 hrs. lab. Offered only in summer at the Chincoteague Bay Field Station. Prereq: C- or higher in ESCI 261.

ESCI 279: 3 s.h.**Experimental**

Experimental

ESCI 281: 3 s.h.**GIS Applications for Earth Sci**

Introduction to the basic concepts of geospatial information systems applications for earth sciences students. Emphasis is on the use of GIS applications for solving problems in the earth sciences. Limited to earth sciences majors or minors who have completed one of the introductory earth sciences courses for majors. ESCI 281 and GEOG 295 may not both be taken for credit. 3 hrs. lec. Prereq: ESCI 221, 241 or 261.

ESCI 282: 3 s.h.**FORTTRAN Programming for Earth Sciences Applications**

Programming in computational methods emphasizing FORTRAN applied to the earth sciences; numerical solution of equations of motion; statistical properties of digital images; analysis of periodical phenomena; use of National Center for Atmospheric Research graphics library. 2 hrs. lec., 2 hrs. lab. Offered in fall. Prereq: MATH 211 and PHYS 231.

ESCI 300: 3-12 s.h.**Co-Op Ed Experience in ESCI**

Co-Op Ed Experience in ESCI

ESCI 321: 4 s.h.**Structural Geology**

Recognition, interpretation and illustration of geological structures; kinematic and dynamic analysis of rock deformation; stress, strain and deformation mechanisms. 3 hrs. lec., 3 hrs. lab., field trips required. Prereq: C- or higher in ESCI 221 and completion of MATH 160.

ESCI 322: 3 s.h.**Environmental Hydrology**

Theory and practice of quantifying hydrologic phenomena; field methods, data manipulation and environmental applications. 2 hrs. lec., 2 hrs. lab. Offered spring. Prereq: minimum of 45 credits, C- or higher in MATH 101 and any 200-level science course that counts towards a science degree, or permission of instructor.

ESCI 326: 4 s.h.**Sedimentation and Stratigraphy (W)**

The origin and composition of sediments and sedimentary rocks, study of the processes involved in the sedimentary cycle, environments of deposition, and the interpretation of ancient environments from sedimentary rocks. 3 hrs. lec., 3 hrs. lab, field trips required. Prereq: ESCI 221 and ENGL 110

ESCI 327: 4 s.h.**Earth Materials**

Identification, crystal chemistry, crystallography and occurrence of common minerals; optical theory and interaction of light with crystals; mineral and rock identification through use of transmitted polarized light; identification, formation, and occurrence of common rocks. 3 hrs. lec., 3 hrs. lab. Offered fall of odd years. Prereq: C- or higher in 221.

ESCI 329: 3 s.h.**Aqueous Geochemistry (W)**

Inorganic chemistry of surface waters; equilibrium thermodynamics, solubility and stability relationships of silicates and calcium carbonates; kinetics, acid-base reactions, redox equilibria; contaminants transport in natural waters; surficial materials weathering. 3 hrs. lec. Prereq: ESCI 221, CHEM 112; ENGL 110.

ESCI 340: 3 s.h.**Cloud Physics & Precip Process**

Cloud types and physical characteristics; cloud formation processes; precipitation types and formation processes; vertical stability and its relation to types of cloud and precipitation formation; lightning and other forms of atmospheric electricity; atmospheric optical phenomena such as rainbows, halos, mirages, etc. 3 hrs. lec. Prereq: C- or higher in ESCI 241, or PHYS 231. Coreq or Prereq: MATH 211.

ESCI 340H: 3 s.h.**H:Physical Meteorology**

ESCI 341: 3 s.h.**Atmospheric Thermodynamics**

First and second principles of thermodynamics, water-air systems, equilibrium of small droplets and crystals, thermodynamic processes in the atmosphere, atmospheric statics, vertical stability and aerological diagrams. 3 hrs. lec. Prereq: C- or higher in ESCI 241. Coreq or Prereq: MATH 311.

ESCI 342: 3 s.h.**Atmospheric Dynamics 1**

Centered difference approximations, total derivative, and basic kinematics; fundamental and apparent forces; mass and momentum conservation; equations of motion and their applications; circulation, vorticity, and divergence. Prereq: C- or higher in ESCI 241 and PHYS 231. Coreq or Prereq: MATH 311.

ESCI 343: 3 s.h.**Atmospheric Dynamics 2**

Ageostrophic wind; quasi-geostrophic theory; theory and properties of atmospheric waves, including gravity waves, sound waves, internal waves, inertial-gravity waves; geostrophic adjustment; atmospheric instabilities, including inertial/slantwise instability, barotropic and baroclinic instability. 3 hrs. lec. Offered in spring. Prereq: ESCI 342.

ESCI 344: 3 s.h.**Tropical Meteorology**

General circulation of the tropics; energy balance; boundary layer; cumulus convection; survey of tropical disturbances including tropical cyclones. 3 hrs. lec. Prereq: C- or higher in ESCI 341, 342.

ESCI 344H: 3 s.h.**H:Tropical Meteorology**

H:Tropical Meteorology

ESCI 345: 3 s.h.**Atmospheric Radiative Transfer**

Quantitative description and analysis of atmospheric radiation and its interaction with atmospheric constituents (gases, aerosol, and clouds) and the land and ocean surfaces. Topics include properties of radiation, the electromagnetic spectrum, reflection and refraction, radiative properties of natural surfaces, thermal emission, atmospheric transmission, atmospheric emission (the Schwarzschild Equation) and absorption, scattering and absorption by molecules and particles, radiative transfer with multiple scattering, numerical modeling of atmospheric radiation, relevance for climate and weather. Prereq: C- or higher in ESCI 241, or PHYS 231. Coreq or Prereq: MATH 311.

ESCI 347: 3 s.h.**Satellite Meteorology**

Orbital and radiative transfer physics applied to satellite meteorology systems. Contemporary applications of satellite remote sensing of the atmosphere, including the retrieval of cloud microphysics and precipitation, the generation of atmospheric vertical profiles of temperature and moisture, the retrieval of wind, and image interpretation in the context of weather forecasting. 3 hrs. lec. Offered in fall of even years. Prereq: ESCI 241; MATH 161 or MATH 163.

ESCI 347H: 3 s.h.**H:Satellite Meteorology****ESCI 348: 2 s.h.****Broadcast Meteorology**

Preparation and presentation of weather information to the public; graphics preparation, television and radio weathercasting; video production. 1 hr. lec. 2 hrs. studio. Offered in spring. Prereq: C- or higher in ESCI 241 or COMM 320.

ESCI 349: 3 s.h.**Chemistry of the Atmosphere (P)**

Theory, application, methods of analysis and instrumentation relevant to a study of the chemistry of the atmosphere. 3 hrs. of integrated lecture/lab/ working group activities. May be used as an elective in meteorology and environmental chemistry if not counted as "P" course. Prereq: Minimum of 36 credit hours, COMM 100, ENGL 110; junior status; CHEM 104 or CHEM 111; and PHYS 132 or PHYS 232.

ESCI 349H: 3 s.h.**Hon: Chem of the Atmosphere (P)****ESCI 350: 3 s.h.****History of Meteorology (D, P)**

Overall intellectual and institutional development of meteorology from Aristotle to present, with emphasis on the 20th century. Historical overviews of dynamic meteorology and numerical weather prediction, observational tools (the history of radar and satellites) and computational devices, cloud microphysics and dynamics, hurricanes, convective storms and climatology. Spotlights key scientists and their role in the advancement of atmospheric sciences. 3 hrs. lec. Prereq: ESCI 107, 109, or ESCI 241; and HIST 101 or 102 or 106, or 340; COMM 100, ENGL 110 and junior status.

ESCI 350H: 3 s.h.**H:History of Meteorology (P)**

H:History of Meteorology

ESCI 362: 3 s.h.**Marine Geology**

Sedimentary and tectonic characteristics of the continental margins and deep ocean basins; principles and processes of sediment transport and deposition in the marine environment; applications of geophysical methods at sea; marine mineral resources. 3 hrs. lec. Offered only in summers of even years at the Chincoteague Bay Field Station. Prereq: C- or higher in ESCI 261 or 221.

ESCI 363: 3 s.h.**Chemical Oceanography**

Oceanic chemical phenomena, including structure of water, salinity, sources and sinks of chemical constituents; chemical interactions at interfaces between hydrosphere and atmosphere, lithosphere and biosphere; biogeochemical cycles of nutrients; the carbon-dioxide-carbonate system; origin and history of seawater; anthropogenic effects. Prereq: C- or higher in ESCI 261 and CHEM 111.

ESCI 366: 3 s.h.**Marine Resources and Policy (D, P)**

This course will give the student a broad background in Marine Resources including biological, transportation, oil and gas, methane hydrates, minerals and freshwater, recreation, endangered species, energy and waste disposal. The course will also give an overview on National and International Law Applied to the marine environment. Topics on Marine policies including marine environmental policy, International fisheries policy, Marine transportation and safety policy, etc. will be discussed and related to geographical, socio-economic and political issues affecting Marine Resources, Sustainability and Marine Conservation. News clips, articles in journals, case studies of issues relevant to the topics above will be discussed in an open, free and debate like atmosphere that is designed to develop student's critical thinking skills in a deliberate and structured way. Prereq: COMM 100 or 100H, ENGL 110 or 110H, junior standing and any 200-level course in ESCI, BIOL or GEOG.

ESCI 366H: 3 s.h.**Hon: Marine Resources/Policy (D, P)**

ESCI 369: 3 s.h.**Physical Oceanography and Climate**

Physical properties of seawater; mass and energy budgets of the ocean; typical distribution of water characteristics, global balances; the conservation equations; equations of motion; fluid motion in rotating systems. Conservation of vorticity; wind and thermohaline circulation; currents and eddies; wind-generated waves; tides and other waves; Exchange of buoyancy and heat fluxes in the atmosphere-ocean boundary layer; Climate Change and the Ocean. A required course for Ocean Sciences and Coastal Studies majors and elective for other earth sciences programs. Combination of lecture and laboratory exercises. 2 hrs. lec., 2 hrs. lab. Offered in fall of odd years. Prereq: ESCI 261 or ESCI 241; MATH 161, PHYS 131 or PHYS 231, or permission of Instructor. 3.000 Credit hours 2.000 Lecture hours 2.000 Lab hours.

ESCI 379: 1-4 s.h.**Experimental**

Experimental

ESCI 380: 3 s.h.**Remote Sensing & Image Interpretation**

Principles of remote sensing; fundamentals of image visualization; radiative transfer equation; use of environmental, meteorological and oceanographic satellites; satellite algorithm and parameter estimation; use of Environment for Visualizing Images (ENVI) software for image analysis and interpretation. Basic computer literacy is assumed. 2 hrs. lec., 2 hrs. lab. Research project is required. Prereq: ESCI 221 or 241 or 261.

ESCI 382: 3 s.h.**Water Wars: Science and Policy (D, P)**

Interdisciplinary investigation of the causes and solutions of water crises. Topics such as the sources of fresh water, the use and consumption of water, and regional and international conflict over water rights will be discussed. Current water crises from across the globe will be used to highlight societal differences in water use and preservation. Prereq: Minimum of 60 credits, ENGL 110 and any ESCI course or permission of instructor.

ESCI 382H: 3 s.h.**H: Water Wars: Science & Policy (D, P)****ESCI 385: 3 s.h.****Global Climate Change: Sci & Policy (P)**

Evolution of the Earth's habitable atmosphere and oceans; mechanisms that control climate processes and change; past global climate change as deciphered through paleoclimatic and paleoceanographic methods; recent rapid climate fluctuations and possible future changes. 3 hrs. lec. Prereq: ENGL 110; ESCI 241 or 261 or GEOG 230.

ESCI 385H: 3 s.h.**H: Climate Chng: Sci & Policy (P)****ESCI 386: 3 s.h.****Sci Prg Lang:**

Use of scientific programming languages for analysis and display of data. Topics include: data types; syntax and control statement; use of plotting and graphics libraries; reading and writing data sets in ASCII, binary, NetCDF, and other formats; spectral analysis; statistical operations; matrix operations. 2 hrs. lec., 2 hrs. lab. Offered in spring. Prereq: ESCI 282 or CSCI 161; MATH 211 and PHYS 231.

ESCI 390: 1-4 s.h.**Topics in the Earth Sciences**

Detailed investigation of a topic of current research interest. Topic to be announced each time course is offered. Credit and meeting hours variable, depending on topic offered. Offered infrequently. Prereq: completion of 60 credits.

ESCI 390H: 1-4 s.h.**Hon: Topics in Earth Science****ESCI 400: 3-12 s.h.****Co-Op Ed Experience in ESCI**

Co-Op Ed Experience in ESCI

ESCI 422: 3-6 s.h.**Geological Field Mapping**

Examination and interpretation of geologic materials and structures in the field. Students prepare a geologic map, stratigraphic column and structural cross-sections of an assigned field area. Prereq: C- or higher in ESCI 321.

ESCI 423: 3 s.h.**Applied Geophysics**

Geophysical methods applied to environmental assessment, resource exploration and civil engineering issues. Topics covered include seismic refraction and reflection, ground-penetrating radar, electrical resistivity, gravity, and geomagnetism. 2 hrs. lec., 2 hrs. lab. Offered fall of even years. Prereq: minimum of 60 credits, C- or higher in MATH 101 and any 200-level science course that counts towards a science degree, or permission of instructor.

ESCI 426: 3 s.h.**Groundwater Resources and Contamination**

Occurrence and behavior of groundwater; groundwater contamination and remediation; groundwater resource assessment, including aquifer test design and analysis; introduction to groundwater modeling. 2 hrs. lec., 2 hrs. lab. Prereq: minimum of 60 credits, C- or higher in MATH 101 and any 200-level science course that counts towards a science degree, or permission of instructor.

ESCI 428: 3 s.h.**Planetary Geology (W)**

Terrestrial geology in the context of the solar system; geochemical evolution of the solar nebula; planetary formation and evolution; comparative planetology, meteoritics; asteroid/cometary impact phenomena. 3 hrs. lec. Offered infrequently. Prereq: ENGL 110, ESCI 222 and CHEM 111.

ESCI 440: 3 s.h.**Space Weather and Environment**

In-depth study of the space environment between the earth and sun; solar-terrestrial interactions; physics of the sun and space weather; observations, modeling and prediction of space weather events; effects on life, property and infrastructure. 3 hrs. lec. Offered in spring of even years. Coreq: MATH 365; Prereq: ESCI 342 and either ESCI 340 or PHYS 233 or permission of instructor.

ESCI 440H: 3 s.h.**Hon: Space Weather/Environment**

ESCI 441: 3 s.h.**Synoptic Meteorology Lecture-Laboratory**

Application of atmospheric dynamics and atmospheric physics to the theoretical and empirical investigation of mid-latitude synoptic-scale meteorological processes. Topics include the diagnosis of synoptic-scale vertical motions, the circulation at fronts and the life cycle of the extratropical cyclone. 3 hrs. lec., 3 hrs. lab. Offered in fall. Prereq: ESCI 340, 341, 343.

ESCI 442: 2 s.h.**Adv Wthr Anlys/Forecstng Pract**

Advanced synoptic and mesoscale weather analysis and forecasting skills. Students perform weather analysis exercises designed to complement the forecast process. Students prepare probabilistic meteorological forecasts and lead post-forecast discussions focused on lessons learned. 1 hr. lec., 2 hrs. lab. Offered in spring. Prereq: C- or higher in ESCI 441 and one semester of Campus Weather Service or by permission of instructor. Coreq: ESCI 444.

ESCI 443: 3 s.h.**Climate Dynamics (W)**

A comprehensive treatment of the components of the climate system, feedback mechanisms and interactions; mean state of the climate system; a detailed and in-depth treatment of the earth-atmosphere radiation balance and general circulation; natural and anthropogenic forcings and their effect on the climate system; climate models; and the current state of climate-observing networks and model validation. 2 hrs. lec., 2 hrs. applications and analysis. Offered in spring. Prereq: ESCI 343 or 369, ENGL 110.

ESCI 444: 4 s.h.**Mesoscale Meteorology**

Application of atmospheric dynamics and atmospheric physics to the theoretical and empirical investigation of mid-latitude mesoscale meteorological processes. Topics include atmospheric sounding analysis, pressure perturbations, mesoscale instabilities, the atmospheric boundary layer, air mass boundaries, convection initiation, organization of convection and tornadoes. 4 hrs. lec. Prereq: ESCI 441.

ESCI 445: 3 s.h.**Num Modeling of Atmos and Ocn**

Methods and mathematical concepts of numerical weather and ocean prediction models. Students must be able to program in one of the following languages: Fortran, C++, or IDL. 3 hrs. lec. Offered in spring of odd-numbered years. Prereq: ESCI 282 or CSCI 161. Coreq or Prereq: ESCI 343 or 365.

ESCI 446: 3 s.h.**Stats & Decision Making in Earth Science**

Descriptive and inference statistics, uncertainty, review of probability, empirical distributions, exploratory data analysis, parametric probability distributions, frequency and Bayesian inference, statistical forecasting and forecast verification, statistics in decision making, time series, multivariate statistics and normal distribution (MVN), principal component analysis (EOF), canonical correlation analysis (CCA), discriminant analysis, cluster analysis, thriving on the edge of chaos, effective complexity. Pre-req: C- or higher in MATH 211

ESCI 447: 3 s.h.**Meteorological Instrumentation (W)**

Devices and platforms used to gather meteorological data; methods of data acquisition, reduction, error analysis and quality assurance; description of instrumentation, measurement techniques, observing systems and their deployment. 2 hrs. lec., 2 hrs. lab. Offered in fall of odd years. Prereq: ENGL 110, PHYS 232 and MATH 235.

ESCI 447H: 3 s.h.**H:Meteorological Instrumentati (W)****ESCI 448: 3 s.h.****Boundary Layers and Turbulence**

Mean boundary layer characteristics; turbulence and its spectrum; governing equations to turbulent flow; prognostic equations for turbulent fluxes and variances; TKE; turbulence closure schemes; similarity theory; simulation techniques; convective and stable boundary layers; boundary layer clouds. 3 hrs. lec. Offered in spring of even years. Prereq: C- or higher in ESCI 342 and MATH 211.

ESCI 449: 3 s.h.**Radar Meteorology**

Algorithms used in the display and interpretation of weather radar data; theory of electromagnetic radiation, principles of radar operation, Doppler radar and interpretation techniques; wind velocity, rainfall rates and detection of individual cells, multiple cells and turbulence. 3 hrs. lec. Offered in spring of even years. Prereq: C- or higher in ESCI 241, MATH 311. Coreq or Prereq: ESCI 342.

ESCI 449H: 3 s.h.**Hon: Radar Meteorology****ESCI 464: 3 s.h.****Ocean Ecosystems (W)**

Advanced ocean sciences course investigating the physical, chemical and biological characteristics of the major pelagic ocean biomes from the polar through equatorial regions of the world ocean. Emphasis will be on the important marine plankton functional groups and how their abundances and rates of production are controlled by the circulation patterns of the ocean, ocean turbulence, food web structure, density stratification, the supply of nutrients and the availability of sunlight, and water transparency. 3 hrs. lec. Prereq: ESCI 363 and ESCI 369 or permission of instructor.

ESCI 465: 3 s.h.**Biological Oceanography**

Intensive summer lecture and field course teaching the physical, chemical and biological factors controlling the structure and dynamics of marine ecosystems. Classroom instruction focuses on theoretical principles concerning the environmental control of phytoplankton communities by sunlight, nutrients and grazing. The dynamics and complexity of marine food webs including the phytoplankton, zooplankton and upper trophic levels. Laboratory and field instruction focuses on ocean monitoring and sampling from research vessels, biomass determination and identification of key plankton species, measurement of the rates of net and gross primary production using oxygen light-dark bottle experiments, and optical and chemical techniques of determining phytoplankton biomass and species composition. Approximately 40-50% of course time is spent in field. Prerequisites: C- or higher in ESCI 261 and completion of BIOL (211 or 221), or permission of instructor.

ESCI 466: 3 s.h.**Environmental Oceanography**

A comprehensive examination of some of the pressing ocean-related environmental issues of the 21st century using critical thinking and quantitative approaches. Emphasis on how human activities are changing ocean ecosystems and environments, and how sound scientific reasoning can reveal true cause-and-effect relationships that then may lead to viable solutions. Includes field and laboratory projects teaching modern techniques of water quality analysis, and case studies of provocative real-world marine environmental problems. 2 hrs. lec., 2 hrs lab. Prereq: ESCI 261 or permission of the instructor.

ESCI 468: 3 s.h.

Ocean Data Analysis and Presentation

Advanced ocean sciences course covering the theory behind the most commonly used techniques of ocean sampling and the analysis and presentation of oceanographic data. In this course we will cover the meaning of data and the common types of oceanographic data, methods of ocean data collection, the meaning and importance of metadata, databases in ocean science community, the idea of geospatial data and the importance of frame of reference and time and space scales of interest, the variety of ways to analyze and present oceanographic data, and how to present data to maximize its informational content. 2 hrs. lec., 2 hrs. lab. Prereq: ESCI 261 or permission of instructor.

ESCI 479: 4 s.h.

Experimental

Experimental

ESCI 489: 1-4 s.h.

Honors Course

Honors Course

ESCI 498: 1-4 s.h.

Independent Study

Supervised independent research in the earth sciences. Subject determined jointly by student and the problem supervisor. Permission of department chair and school dean required.

ESCI 499: 1-4 s.h.

Departmental Honors

Departmental Honors

ESCI 500: 3-12 s.h.

Co-Op Ed Experience in ESCI

Co-Op Ed Experience in ESCI