ATMOSPHERIC AND OCEANIC SCIENCES (ATOC)

Courses

ATOC 1050 (3) Weather and the Atmosphere
Introduces principles of modern meteorology for nonscience majors, with emphasis on scientific and human issues associated with severe weather events. Includes description, methods of prediction, and impacts of blizzards, hurricanes, thunderstorms, tornadoes, lightning, floods, and firestorms.
Additional Information: GT Pathways: GT-SC2 -Natural Physicl Sci:Lec Crse w/o Req Lab
Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Natural Science

ATOC 1060 (3) Our Changing Environment: El Nino, Ozone, and Climate
Discusses the Earth's climate for nonscience majors, focusing on the role of the atmosphere, oceans, cryosphere and land surface. Describes the water cycle, atmospheric circulations and ocean currents, and how they influence global climate, El Nino and the ozone hole. Discusses human impacts from climate change.
Recommended: Prerequisite ATOC 1050.
Additional Information: Arts Sci Core Curr: Natural Science Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 1070 (1) Weather and the Atmosphere Laboratory
Illustrates fundamentals of meteorology with laboratory experiments. Covers collection, analysis and discussion of data related to local weather. Uses computers for retrieval and interpretation of weather data from Colorado and across the U.S. Optional lab for ATOC 1050.
Recommended: Prerequisite or corequisite ATOC 1050.
Additional Information: GT Pathways: GT-SC1 - Natural Physcal Sci:Lec Crse w/ Req Lab
Arts Sci Core Curr: Natural Science Lab
Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences
MAPS Course: Natural Science Lab or Lab/Lec

ATOC 2050 (3) Introduction to Atmospheric Research
Uses real world data to investigate the basic physical processes that drive the coupled atmosphere-ocean system (e.g., energy distribution, phase changes, stability, winds and currents). Students will apply logic to predict how processes are impacted as different environmental characteristics change and develop skills in graphical literacy, investigative thinking, societal and personal relevancy, and communication.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 2500 (1-3) Special Topics in Atmospheric and Oceanic Sciences - Lower Division
Acquaints students at the lower division level with current research in atmospheres, oceans and climate (Topics may vary each semester). Students may register for more than one section of this course in the same semester. Recommended restriction: students with 0-56 credits (Freshmen or Sophomores).
Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.
Recommended: Prerequisite or corequisite will vary depending on topic.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 3050 (3) Principles of Weather
Explores the processes that influence middle latitude weather including atmospheric thermodynamics, cloud and precipitation processes, atmospheric dynamics, air masses and fronts, and mid-latitude cyclones. Recitations and homework assignments will allow students to apply these concepts to real weather data through analysis of weather maps, thermodynamics diagrams and conceptual models.
Recommended: Prerequisites ATOC 1050 or ATOC major.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 3070 (3) Introduction to Oceanography
Explores Earth's dynamic oceans. Discusses the disciplines of oceanography including marine geology, chemistry, biology and physical oceanography with emphasis on global change. Specific topics may include: tectonics, currents, biogeochemical cycles, ecology and global warming.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 3070
Recommended: Prerequisite any 1000-level ATOC or GEOL course or ATOC major.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 3180 (3) Aviation Meteorology
Familiarizes students with a wide range of atmospheric behavior pertinent to air travel: rudiments of aerodynamics; aircraft stability and control; atmospheric circulation, vertical motion, turbulence and wind shear; fronts, clouds and storms.
Recommended: Prerequisite ATOC 1050 or ATOC major.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 3300 (3) Analysis of Climate and Weather Observations
Discusses instruments, techniques and statistical methods used in atmospheric observations. Covers issues of data accuracy and analysis of weather maps. Provides application to temperature and precipitation records, weather forecasting and climate change trends. Uses computers to access data sets and process data.
Equivalent - Duplicate Degree Credit Not Granted: GEOG 3301
Recommended: Prerequisites ATOC 1050 or ATOC 1060 or ATOC 3600 or GEOG 3601 or ENVS 3600 or GEOG 1001 and one semester calculus.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 3500 (3) Air Chemistry and Pollution
Examines the composition of the atmosphere and sources of gaseous and particulate pollutants: their chemistry, transport and removal from the atmosphere. Applies general principles to acid rain, smog and stratospheric ozone depletion.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 3151
Recommended: Prerequisite one semester of college-level chemistry or one year of high school chemistry.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 3600 (3) Principles of Climate
Describes the basic components of the climate system: the atmosphere, ocean, cryosphere and lithosphere. Investigates the basic physical processes that determine climate and link the components of the climate system. Covers the hydrological cycle and its role in climate, climate stability and global change.
Equivalent - Duplicate Degree Credit Not Granted: GEOG 3601 and ENVS 3600
Recommended: Prerequisites one semester of calculus and ATOC 1060 or ATOC 3300 or GEOG 3301 or GEOG 1001 or ATOC major.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 3700 (3) Course-Based ATOC Research Experience
In this course-based research experience in Atmospheric and Oceanic Sciences, students will learn about how scientific research works as well as gain first research experience in Atmospheric and Oceanic Sciences by working on an authentic research project. Specifically, students will learn how to understand scientific articles, how to develop subject-matter expertise, how to design a scientific research project, how to analyze and interpret data, and how to present their results to other scientists. Formerly offered as a special topics course.
Recommended: Prerequisite ATOC 1060 or ATOC 3600, and 1 semester of programming or equivalent self-study before the beginning of the class is required.

ATOC 3720 (3) Planets and Their Atmospheres
Explores the physics and chemistry of the atmospheres of Mars, Venus, Jupiter, Saturn, and Titan. Examines evolution of the atmospheres of Earth, Venus, and Mars; and the escape of gases from the Galilean satellites, Titan and Mars; the orbital characteristics of moons, planets, and comets. Uses recent results of space exploration. Elective for APS major and minor.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 3720
Requisites: Requires prerequisite courses of PHYS 1120 and (APPM 1360 or MATH 2300) and prerequisite or corequisite course of ASTR 2100 or MATH 2400 or APPM 2350 (all minimum grade C-).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4020 (1) Seminar in Atmospheric and Oceanic Sciences
Explores current research areas; students read selected papers, give presentations and participate in discussions; fellowship and internship opportunities; discussion on practical skills necessary for academic and professional life; career-building activities with outside speakers from academia and industry. May be repeated for a total of 6 credit hours within the degree as long as the topic is different. May be repeated for a total of 3 credit hours within a semester.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

ATOC 4200 (3) Biogeochemical Oceanography
Provides a large-scale synthesis of the processes impacting ocean biogeochemistry. Transforms theoretical understanding into real-world applications using oceanographic data and models. Topics include: chemical composition, biological nutrient utilization and productivity, air-sea gas exchange, carbonate chemistry, ocean acidification, ocean deoxygenation, iron fertilization, biogeochemical climate feedbacks and more.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5200
Recommended: Prerequisites one semester of calculus and one semester of chemistry.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4215 (3) Descriptive Physical Oceanography
Introduces descriptive and dynamical physical oceanography, focusing on the nature and dynamics of ocean currents and their role in the distribution of heat and other aspects of ocean physics related to the Earth's climate. Dynamical material limited to mathematical descriptions of oceanic physical systems.
Requisites: Restricted to students with 57-180 credits (Juniors or Seniors).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4500 (1-3) Special Topics in Atmospheric and Oceanic Sciences - Upper Division
Acquaints students at the upper division level with current research in atmospheres, oceans, and climate. Topics may vary each semester. Students may register for more than one section of this course in the same semester.
Repeatable: Repeatable for up to 18.00 total credit hours. Allows multiple enrollment in term.
Recommended: students with 57-180 credits (Juniors or Seniors).
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4550 (3) Mountain Meteorology
Investigating main processes that control weather and climate in the western United States and other mountain ranges around the world is the emphasis of this course. Provides an advanced survey of synoptic, mesoscale, and microscale meteorology in complex terrain including orographically modified cyclone evolution, front-mountain interactions, terrain and thermally driven flows, mountain waves, downslope winds, and orographic precipitation.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5550
Recommended: Prerequisite ATOC 1050 or ATOC major.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4700 (3) Weather Analysis & Forecasting
Utilizing a range of operational weather observations to analyze current weather conditions, providing hands-on experience interpreting observations and relating those observations to the physical principles that govern atmospheric behavior is the course emphasis. It focuses on how to read weather reports, analyze observations, and how to prepare weather maps to analyze current conditions and how to interpret numerical weather forecasts.
Recommended: Prerequisite ATOC 1050 or ATOC 1060 or ATOC 4720 or ATOC major.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4710 (3) Introduction to Atmospheric Physics
Provides a fundamental overview of the physics of Earth's atmosphere. Topics include atmospheric composition and structure, atmospheric radiation and optics (rainbows, halos and other phenomena), atmospheric thermodynamics, cloud physics and atmospheric electricity and lightning. Including both descriptive and quantitative approaches to the subject material. Where applicable, observations from the ATOC Skywatch Observatory will be introduced.
Recommended: Prerequisite one year of calculus and one year of physics with calculus.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4720 (3) Atmospheric Dynamics
Introduces the fundamental physical principles that govern the atmospheric circulations across a range of spatial and temporal scales and provides a quantitative description and interpretation of a wide range of atmospheric phenomena. Topics include atmospheric forces, governing equations, balanced and unbalanced flows, atmospheric waves and mid-latitude cyclones.
Recommended: Prerequisite one year of calculus and one semester of physics with calculus.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4730 (3) Physical Oceanography and Climate
Introduces the field of physical oceanography, with emphasis on the ocean's interaction with the global atmosphere. Analysis of the ocean's heat, salt, and momentum budgets, wind-driven and thermohaline circulations, climate cycles including El Nino, and the ocean's role in climate change. Theory complemented by state-of-the-art observations and models. Department recommended prerequisites: ATOC 1060 or ATOC 3070 or ATOC 3600 and one semester of calculus.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5730
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4740 (3) Dynamics of Past Climate Changes: Lessons for the Future
Studies past changes in the Earth¿s climate and their application to predict future climate changes. Combines theoretical understanding of the climate system, computer models, and records of past changes from geological archives to understand drivers of past and future changes in climate. Emerging and inter-disciplinary area in climate research including paleoclimatology, climate theory, and modelling. Students work individually and in groups to formulate hypotheses that ca be tested using paleoclimate records and model simulations. Formerly offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5720
Recommended: Prerequisite Prior college-level coursework in Chemistry and Physics, and least two of the following courses - ATOC 1060, ATOC 4730, ATOC 5730, GEOL 3040, GEOL 3070, GEOL 3820, GEOL 4060, or GEOL 4070.

ATOC 4750 (3) Desert Meteorology and Climate
Introduces students to the dynamic causes of deserts in the context of atmospheric processes and land-surface physics. Discusses desert severe weather, desert microclimates, human impacts and desertification, inter-annual variability in aridity (drought), the effects of deserts on global climate and the impact of desert climate on humans.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5750
Recommended: Prerequisites one semester of calculus and ATOC 1050 or ATOC 1060 or ATOC 3600 or ATOC major.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4760 (3) Physics and Chemistry of Clouds and Aerosols
Clouds and aerosols are important components of the climate system, impact remote sensing, affect human health, and are tightly coupled to radiation, chemistry and dynamics. This class covers the basic concepts in cloud and aerosol physics and chemistry in the context of the leading problems in climate, Earth history, air pollution, and weather. Examples include: dust storms; volcanic eruptions and climate; the extinction of the dinosaurs; nuclear winter; clouds and climate; thunderstorms, and lightning.
Recommended: junior and senior level students.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4770 (3) Renewable Energy Meteorology
Explores the complex interactions of the atmosphere and wind energy generation. Surveys wind turbine designs. Explores planetary boundary layer dynamics, traditional and novel wind measurement methods, forecasting methods, wind turbine and wind farm wakes, wind farm optimization, sound propagation from wind plants, climate change impacts on wind resources and the impacts of wind plants on local environments.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5770
Recommended: Prerequisite ATOC 1050 or ATOC major.
Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4780 (3) Ice Sheets and Climate
Covers the role of ice sheets in the climate system over a range of time (millions of years ago to the long-term future) scales, and presents the interactions between ice sheets, the ocean, and the atmosphere. Students will be introduced to, and work with, observational and modeling methods and data that conceptualize ice sheet climate and related topics.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5780
Recommended: Prerequisite Basic programming experience (python, Matlab, or equivalent), basic knowledge of calculus, basic knowledge of algebra and at least one ATOC course at the 1000, 2000, or 3000 level with a grade of C- or higher.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4800 (3) Policy Implications of Climate Controversies
Examines controversial issues related to the environment, including climate change. Covers scientific theories and the intersection between science and governmental policy. Includes discussion, debate and critical reading of textual materials. Department enforced prerequisite: ATOC 1060 or ATOC 3600.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5000 and ENVS 5830
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4815 (3) Scientific Programming, Data Analysis and Visualization Laboratory
Teaches programming in python, as well as analysis skills for accessing, analyzing and visualizing data that are commonly used in the atmospheric and oceanic sciences. Basic data analysis includes curve fitting and re-gridding/aggregation of satellite observations or meteorological data for global climatologies. The course content is primarily conveyed through hands-on code development. A final project, involving the independent analysis and visualization of a scientific data set, integrates skills acquired throughout the course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5815
Recommended: Requisites prior experience with Python or a basic programming course such as CSCI 1300 or equivalent, basic knowledge of calculus and algebra.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab
Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4830 (3) Remote Sensing Lab
Fundamentals of remote sensing of the atmosphere and ocean including fundamentals of atmospheric radiation and inverse methods for deriving geophysical variables from measurements. Principles of satellite and ground-based active (lidar and radar) and passive remote sensing methods, instrumentations, and applications. Lectures will include both descriptive and quantitative approaches to the subject material and include in-class demonstrations and measurements and data from the ATOC Skywatch Observatory and NASA satellites.
Recommended: Prerequisites one year of calculus and one year of physics with calculus.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4840 (3) Field Observations and Measurements Laboratory
This course introduces students to all aspects of observing the atmospheric state including issues associated with observational and instrument errors, planning and executing measurement campaigns and analyzing and presenting results based on data collected during field campaigns. During the semester students will plan, conduct and analyze data from two atmospheric field campaigns conducted near Boulder, CO using a suite of meteorological sensors.
Recommended: Prerequisites ATOC 1050 or ATOC 3050.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4850 (3) Numerical Methods Laboratory
Teach students how to convert physical descriptions of the earth system into numerical models. Students will learn how to make assumptions to simplify complex systems, how to discretize and code mathematical equations so they can be solved on a computer, and how to assess if the results are reasonable. The course content is primarily conveyed through hands-on code development in python. A final project integrates skills acquired throughout the course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5850
Recommended: Prerequisites ATOC 4815 or ATOC 5815, Calculus 1, Calculus 2, Differential Equations, Linear Algebra, and a basic knowledge of/interest in atmospheric, oceanic, climatic, or cryospheric physics.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4860 (3) Data Science Lab
The goals of this course are twofold: 1) providing a working knowledge of basic data science methods used for temporal and spatial analysis of atmospheric and oceanic data, to turn the data into clear insights via a computer program, 2) develop skills to work in a group and explain data science techniques to an audience with a broad range of expertise. The course covers: probability distributions and statistical indices; hypothesis testing; linear and multilinear regression; an intro to machine learning; an intro to Gaussian processes. This ¿learning-by-doing¿ course is recommended for senior level students. Formerly offered as a special topics course.

ATOC 4870 (3) Climate Modeling Laboratory
Climate models solve equations describing the earth system. This course provides an overview of climate modeling. Standard climate model approaches and experiments are presented, and then used in companion exercises. This course will provide students with real-world experience running a climate model used internationally for climate science and policy. This course is aimed at upper level undergraduate students. Recommended restriction: Junior or Senior ATOC students.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5870
Recommended: Prerequisite Experience with programming, Calculus, Differential Equations and Linear Algebra.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences Arts Sci Gen Ed: Distribution-Natural Sci Lab

ATOC 4875 (3) Weather Modeling Laboratory
In this laboratory course, students simulate the atmosphere using a numerical weather prediction model (WRF) and explore the physical and numerical basis of the system of equations that underpin numerical weather prediction models. In addition to developing technical skills with WRF and visualizing its output with python, students explore applications of numerical modeling of the atmosphere, such as land-sea breezes, hurricanes, mesoscale convective systems, and the daily cycle of the boundary layer. Recommended restriction: Junior or Senior class standing. Previously offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5875
Requisites: Requires prerequisite course of ATOC 1050 or ATOC 3050 or ATOC 4700 or ATOC 4710 or ATOC 4720 (all minimum grade C-).
Recommended: Prerequisite Experience with computer science and data visualization such as ATOC 4815 and some experience with Unix/Linux.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sci Lab Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4880 (3) Mesoscale Meteorology
Provides a comprehensive study of the structure, evolution, and dynamics of atmospheric phenomena on the mesoscale, which have horizontal scales ranging from a few to several hundred kilometers. Topics include land/sea breezes, horizontal convective rolls, drylines, deep convective storms, outflow boundaries, tornadoes, mesoscale convective systems, terrain induced airflows, mountain waves and the mesoscale aspects of extratropical cyclones. Previously offered as a special topics course. Recommended restriction: Senior or Fifth-Year Senior standing.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5880
Recommended: Prerequisites One year of Calculus, one year of Physics with Calculus, and at least one ATOC fundamental or core course, preferably ATOC 3050 or ATOC 4720.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences

ATOC 4890 (3) Synoptic Dynamic Meteorology
Weather conditions at middle latitudes are characterized by complex interactions between air masses, fronts, cyclones, and anticyclones. These interactions are governed by a set of elegant mathematical equations that describe the behavior of the atmosphere. Students will manipulate and apply these equations in real time in order to diagnose the development and evolution of a variety of synoptic-scale weather systems, including fronts, jet streams, and extratropical cyclones. Recommended restriction: Junior and Senior-level students. Previously offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5890
Recommended: Prerequisite ATOC 3050, ATOC 4720, one year of Calculus, and one semester of Physics with Calculus.
Additional Information: Arts Sci Gen Ed: Distribution-Natural Sciences Arts Sci Gen Ed: Distribution-Natural Sci Lab

ATOC 4900 (1-3) Independent Study
Department enforced prerequisite: instructor consent.
Repeatable: Repeatable for up to 6.00 total credit hours.

ATOC 4950 (1-3) Honors Thesis
Students work independently on a research topic under the guidance of a faculty member. A written thesis and an oral presentation of the work are required. Registration by arrangement and with consent of faculty mentor. Department enforced prerequisite: minimum 3.00 GPA.
Requisites: Restricted to students with 57-180 credits (Juniors or Seniors).
Additional Information: Arts Sciences Honors Course

ATOC 4990 (1-3) Internship
This course is designed to provide junior and senior ATOC majors with the opportunity to work hands-on in the community and to gain practical knowledge and experience in both research and industry. Participation in the program requires both on-site and academic work. 0.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Recommended: Students should have junior or senior standing (at the time of the internship) and have a minimum cumulative GPA of 2.

ATOC 5000 (3) Critical Issues in Climate and the Environment
Discusses current issues such as ozone depletion, global warming and air quality for graduate students in nonscientific fields. Provides the scientific background necessary to understand, follow scientific developments and critically evaluate these issues.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4800 and ENVS 5830
Requisites: Restricted to graduate students only.

ATOC 5050 (3) Atmospheric Thermodynamics and Dynamics
Covers atmospheric thermodynamics and dynamics and the underlying governing laws and mathematical and physical principles. Topics include atmospheric composition and thermodynamics, conservation laws and atmospheric governing equations, geostrophic balance and balanced flows, vorticity dynamics and boundary layers. ATOC graduate core course.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite one year of calculus-based physics and math through differential equations.

ATOC 5051 (3) Introduction to Physical Oceanography
Provides fundamental knowledge of observations,, theory, dynamics and modeling in physical oceanography. Promotes critical thinking and the development of skills for data analysis and interpretation. ATOC graduate core course.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites one year of calculus-based physics and math up through differential equations.

ATOC 5060 (3) Dynamics of the Atmosphere and Oceans
Examines large-scale motions in a stratified rotating atmosphere and ocean, and quasi-geostrophic flow, barotropic and baroclinic instabilities, cyclogenesis, global circulations and boundary layer processes. Ageostrophic motions, including Kelvin waves, internal gravity waves and the theory of frontogenesis are also considered. ATOC graduate core course.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite ATOC 5050, one year of calculus-based physics and math up through differential equations.

ATOC 5061 (3) Advanced Ocean Dynamics and Air-Sea Coupled ENSO Mechanisms
Explores the existing theories of the El Niño and Southern Oscillation (ENSO) ocean-atmosphere coupled mechanisms, theory of the thermocline in a quasi-geostrophic system, and dynamics of the Atlantic Meridional Overturning Circulation (AMOC). Covers physical mechanisms, associated mathematical equations, and numerical model simulations. Discusses their direct research applications in understanding the past, present and future climate variability and change. Offered once per year.
Repeatable: Repeatable for up to 9.00 total credit hours.
Requisites: Restricted to graduate students only.
Recommended: Prerequisites ATOC 5400, ATOC 5051 or ATOC 5060 and one year of calculus-based physics and math including differential equations.

ATOC 5151 (3) Atmospheric Chemistry
Reviews basic kinetics and photochemistry of atmospheric species and stratospheric chemistry with emphasis on processes controlling ozone abundance. Tropospheric chemistry focusing on photochemical smog, acid deposition, oxidation capacity of the atmosphere and global climate change. ATOC graduate core course.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5151
Requisites: Restricted to graduate students only.
Recommended: Prerequisite one semester of college-level chemistry.

ATOC 5152 (3) Advanced Atmospheric Chemistry
Follows Graduate Atmospheric Chemistry (ATOC 5151) and explores advanced topics in atmospheric chemistry, such as secondary aerosol formation, oxidant formation, the chemistry of global climate change and/or design of advanced laboratory experiments.
Equivalent - Duplicate Degree Credit Not Granted: CHEM 5152
Recommended: Prerequisite CHEM 5151 or ATOC 5151.
Grading Basis: Letter Grade

ATOC 5200 (3) Biogeochemical Oceanography
Provides a large-scale synthesis of the processes impacting ocean biogeochemistry. Transforms theoretical understanding into real-world applications using oceanographic data and models. Topics include: chemical composition, biological nutrient utilization and productivity, air-sea gas exchange, carbonate chemistry, ocean acidification, ocean deoxygenation, iron fertilization, biogeochemical climate feedbacks and more.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4200
Requisites: Restricted to graduate students only.

ATOC 5215 (3) Descriptive Physical Oceanography
Introduces descriptive and dynamical physical oceanography, focusing on the nature and dynamics of ocean currents and their role in the distribution of heat and other aspects of ocean physics related to the Earth's climate. Dynamical material limited to mathematical descriptions of oceanic physical systems.
Requisites: Restricted to graduate students only.

ATOC 5235 (3) Introduction to Atmospheric Radiative Transfer and Remote Sensing
Examines fundamentals of radiative transfer and remote sensing with primary emphasis on the Earth's atmosphere; emission, absorption and scattering by molecules and particles; multiple scattering; polarization; radiometry and photometry; principles of inversion theory; extinction- and emission-based passive remote sensing; principles of active remote sensing; lidar and radar; additional applications such as the greenhouse effect and Earth's radiative energy budget. ATOC graduate core course. Department enforced prerequisites: one year of calculus-based physics, and math up through differential equations.
Requisites: Restricted to graduate students only.

ATOC 5300 (3) The Global Carbon Cycle
Covers the role of the ocean, terrestrial biosphere, and atmosphere in the global carbon cycle. Specific topics include marine carbonate chemistry, biological production, terrestrial fluxes, anthropogenic emissions, and the evolution of the global carbon cycle in a changing climate.
Requisites: Restricted to graduate students only.

ATOC 5400 (3) Introduction to Fluid Dynamics
Covers equations of fluid motion relevant to planetary atmospheres and oceans and stellar atmospheres; effects of rotation and viscosity; and vorticity dynamics, boundary layers and wave motions. Introduces instability theory, nonlinear equilibration and computational methods in fluid dynamics. Department enforced prerequisite: partial differential equations or equivalent.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 5400 and PHYS 5400
Requisites: Restricted to graduate students only.

ATOC 5500 (1-3) Special Topics in Atmospheric and Oceanic Sciences
Acquaints students with current research in atmospheres, oceans, and climate. Topics may vary each semester. Students may register for more than one section of this course in the same semester. Formerly ATOC 7500.
Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

ATOC 5540 (3) Mathematical Methods
Applied mathematics course; provides necessary analytical background for courses in plasma physics,fluid dynamics, electromagnetism, and radiative transfer. Covers integration techniques, linear and nonlinear differential equations, WKB and Fourier transform methods, adiabatic invariants, partial differential equations, integral equations, and integrodifferential equations.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 5540
Requisites: Restricted to graduate students only.

ATOC 5550 (3) Mountain Meteorology
Investigating main processes that control weather and climate in the western United States and other mountain ranges around the world is the emphasis of this course. Provides an advanced survey of synoptic, mesoscale, and microscale meteorology in complex terrain including orographically modified cyclone evolution, front-mountain interactions, terrain and thermally driven flows, mountain waves, downslope winds, and orographic precipitation.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4550
Requisites: Restricted to graduate students only.

ATOC 5560 (3) Radiative Processes in Planetary Atmospheres
Application of radiative transfer theory to problems in planetary atmospheres, with primary emphasis on the Earth's atmosphere; principles of atomic and molecular spectroscopy; infrared band representation; absorption and emission of atmospheric gases; radiation flux and flux divergence computations; radiative transfer and fluid motions; additional applications such as the greenhouse effect, inversion methods and climate models. Department enforced prerequisite: ATOC 5235.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 5560
Requisites: Restricted to graduate students only.

ATOC 5600 (3) Physics and Chemistry of Clouds and Aerosols
Examines the physics and chemistry of clouds and aerosols in the planetary atmospheres, where they impact climate, atmospheric chemistry, remote sensing and weather. Applies basic microphysical, radiative and chemical processes affecting particles to issues in current literature. ATOC graduate core course.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite one semester of college-level chemistry and calculus-based physics and math up through differential equations.

ATOC 5730 (3) Physical Oceanography and Climate
Introduces the field of physical oceanography, with emphasis on the ocean's interaction with the global atmosphere. Analysis of the ocean's heat, salt, and momentum budgets, wind-driven and thermohaline circulations, climate cycles including El Nino, and the ocean's role in climate change. Theory complemented by state-of-the-art observations and models. Department recommended prerequisites: ATOC 1060 or ATOC 3070 or ATOC 3600 and one semester of calculus.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4730
Requisites: Restricted to graduate students only.

ATOC 5740 (3) Dynamics of Past Climate Changes: Lessons for the Future
Studies past changes in the Earth¿s climate and their application to predict future climate changes. Combines theoretical understanding of the climate system, computer models, and records of past changes from geological archives to understand drivers of past and future changes in climate. Emerging and inter-disciplinary area in climate research including paleoclimatology, climate theory, and modelling. Students work individually and in groups to formulate hypotheses that ca be tested using paleoclimate records and model simulations. Formerly offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4740
Recommended: Prerequisites At least two of the following courses - ATOC 5050, ATOC 5051, ATOC 5060, ATOC 5300, ATOC 5730, ATOC 5870, GEOL 5060, GEOL 5305, GEOL 5430, or GEOL 5675.

ATOC 5750 (3) Desert Meteorology and Climate
Introduces students to the dynamic causes of deserts in the context of atmospheric processes and land-surface physics. Discusses desert severe weather, desert microclimates, human impacts and desertification, inter-annual variability in aridity (drought), the effects of deserts on global climate and the impact of desert climate on humans.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4750
Requisites: Restricted to graduate students only.

ATOC 5770 (3) Wind Energy Meteorology
Explores the complex interactions of the atmosphere and wind energy generation. Surveys wind turbine designs. Explores planetary boundary layer dynamics, traditional and novel wind measurement methods, forecasting methods, wind turbine and wind farm wakes, wind farm optimization, sound propagation from wind plants, climate change impacts on wind resources and the impacts of wind plants on local environments.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4770
Requisites: Restricted to graduate students only.

ATOC 5780 (3) Ice Sheets and Climate
Covers the role of ice sheets in the climate system over a range of time (millions of years ago to the long-term future) scales, and presents the interactions between ice sheets, the ocean, and the atmosphere. Students will be introduced to, and work with, observational and modeling methods and data that conceptualize ice sheet climate and related topics.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4780
Requisites: Restricted to graduate students only.
Recommended: Prerequisites Basic knowledge of calculus, algebra and programming experience (python, Matlab, or equivalent).

ATOC 5815 (3) Scientific Programming, Data Analysis and Visualization Laboratory
Teaches programming in python, as well as analysis skills for accessing, analyzing and visualizing data that are commonly used in the atmospheric and oceanic sciences. Basic data analysis includes curve fitting and re-gridding/aggregation of satellite observations or meteorological data for global climatologies. The course content is primarily conveyed through hands-on code development. A final project, involving the independent analysis and visualization of a scientific data set, integrates skills acquired throughout the course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4815
Requisites: Restricted to graduate students only.

ATOC 5830 (3) Topics in Planetary Science
Examines current topics in planetary science, based on recent discoveries, spacecraft observations and other developments. Focuses on a specific topic each time the course is offered, such as Mars, Venus, Galilean satellites, exobiology, comets or extrasolar planets. Department enforced prerequisite: restricted to graduate students in the physical sciences.
Equivalent - Duplicate Degree Credit Not Granted: GEOL 5830 and ASTR 5830
Repeatable: Repeatable for up to 9.00 total credit hours.
Requisites: Restricted to graduate students only.

ATOC 5835 (1) Seminar in Planetary Science
Studies current research on a topic in planetary science. Students and faculty give presentations. Subjects may vary each semester. Department enforced prerequisite: senior level undergraduate physics.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 5835 and GEOL 5835
Repeatable: Repeatable for up to 4.00 total credit hours.
Requisites: Restricted to graduate students only.

ATOC 5850 (3) Numerical Methods Laboratory
Teach students how to convert physical descriptions of the earth system into numerical models. Students will learn how to make assumptions to simplify complex systems, how to discretize and code mathematical equations so they can be solved on a computer, and how to assess if the results are reasonable. The course content is primarily conveyed through hands-on code development in python. A final project integrates skills acquired throughout the course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4850
Requisites: Restricted to graduate students only.
Recommended: Prerequisites ATOC 4815 or ATOC 5815, Calculus 1, Calculus 2, Differential Equations, Linear Algebra, and a basic knowledge of/interest in atmospheric, oceanic, climatic, or cryospheric physics.

ATOC 5860 (3) Objective Data Analysis Laboratory
Teaches the extraction of information from data using statistical methods via a computer program. The goals of this course are: 1) to learn and apply tools to objectively analyze atmospheric and oceanic data, 2) to critically evaluate research using these tools. The course covers hypothesis testing, compositing, regression, principal component analysis, time series analysis, filtering, and data assimilation. This ¿learning-by-doing¿ course is aimed at advanced graduate students conducting ATOC-related research.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite ATOC 4810 or 5810, and familiarity with linear algebra, basic calculus, github and jupyter.

ATOC 5870 (3) Climate Modeling Laboratory
Climate models solve equations describing the earth system. This course provides an overview of climate modeling. Standard climate model approaches and experiments are presented, and then used in companion exercises. This course will provide students with real-world experience running a climate model used internationally for climate science and policy.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4870
Requisites: Restricted to graduate students only.

ATOC 5875 (3) Weather Modeling Laboratory
In this laboratory course, students simulate the atmosphere using a numerical weather prediction model (WRF) and explore the physical and numerical basis of the system of equations that underpin numerical weather prediction models. In addition to developing technical skills with WRF and visualizing its output with python, students explore applications of numerical modeling of the atmosphere, such as land-sea breezes, hurricanes, mesoscale convective systems, and the daily cycle of the boundary layer. Previously offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4875
Requisites: Restricted to graduate students only.
Recommended: Prerequisite Experience with computer science and data visualization and some experience with Unix/Linux is recommended.

ATOC 5880 (3) Mesoscale Meteorology
Provides a comprehensive study of the structure, evolution, and dynamics of atmospheric phenomena on the mesoscale, which have horizontal scales ranging from a few to several hundred kilometers. Topics include land/sea breezes, horizontal convective rolls, drylines, deep convective storms, outflow boundaries, tornadoes, mesoscale convective systems, terrain induced airflows, mountain waves and the mesoscale aspects of extratropical cyclones. Previously offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4880
Requisites: Restricted to graduate students only.
Recommended: Prerequisites One year of Calculus, one year of Physics with Calculus, and at least one fundamental ATOC course.

ATOC 5890 (3) Synoptic Dynamic Meteorology
Weather conditions at middle latitudes are characterized by complex interactions between air masses, fronts, cyclones, and anticyclones. These interactions are governed by a set of elegant mathematical equations that describe the behavior of the atmosphere. Students will manipulate and apply these equations in real time in order to diagnose the development and evolution of a variety of synoptic-scale weather systems, including fronts, jet streams, and extratropical cyclones. Previously offered as a special topics course.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 4890
Requisites: Restricted to graduate students only.
Recommended: Prerequisite ATOC 3050, ATOC 4720, one year of Calculus, and one semester of Physics with Calculus.

ATOC 5900 (1-6) Independent Study
Students may register for more than one section of this course in the same semester.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

ATOC 5930 (1-3) Internship
This course is designed to offer ATOC graduate students with the opportunity to work hands-on in the community and to gain practical knowledge and experience in both research and industry. Participation in the program requires both on-site and academic work.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite Minimum of 3.00 cumulative GPA.

ATOC 6020 (1) Seminar in Atmospheric and Oceanic Sciences
Studies an area of current research in the atmospheric and oceanic sciences. Students read selected papers from the literature. Students and faculty give presentations and participate in discussions. May be repeated for a total of 6 credit hours within the degree. May be repeated for a total of 3 credit hours within a semester.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.

ATOC 6100 (3) Modeling Weather and Climate
Discusses background theory and procedures used for modeling climate on a variety of space and time scales. Includes numerical simulation of weather and climate with models in a hierarchy of complexity, assessments of error growth, prediction of circulations and impact of radiative and other influences. Explores various numerical methods, develops core computing skills and considers data handling and visualization. Consists of a combination of lectures and laboratory.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite ATOC 5050 or calculus.

ATOC 6700 (1) Weather Forecasting and Discussion
Explores the techniques used to make short-term weather forecasts in the mid-latitudes using real-time weather observations, numerical forecast model output and conceptual models of mid-latitude weather phenomena. Students will be required to develop and defend conceptual models of the short-term evolution of the weather and will conduct detailed post-forecast analysis of successful and unsuccessful forecasts.
Repeatable: Repeatable for up to 3.00 total credit hours.
Requisites: Restricted to graduate students only.
Recommended: Prerequisite ATOC 5050.

ATOC 6800 (3) Scientific Writing
Writing is the core of how we communicate our scientific findings. Successful science writing tells a compelling story and makes it easy for the reader to understand our results and their implications. In this hand-on class, student use their own research results to work on developing scientific writing skills that will increase the impact of their papers as well as make writing more enjoyable by learning how to approach the writing and editing process. Department enforced requisite: Students need to have their own research results first and at least one main conclusion from it in order to take this class.
Requisites: Restricted to graduate students only.

ATOC 6940 (1) Master's Candidate for Degree
Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.
Repeatable: Repeatable for up to 3.00 total credit hours.
Requisites: Restricted to graduate students only.

ATOC 6950 (1-6) Master's Thesis
Requisites: Restricted to graduate students only.

ATOC 8990 (1-10) Doctoral Dissertation
All doctoral students must register for not fewer than 30 hours of dissertation credit as part of the requirements for the degree. For a detailed discussion of doctoral dissertation credit, refer to the Graduate School section.
Requisites: Restricted to graduate students only.