ATMOSPHERIC AND OCEANIC SCIENCES

The Department of Atmospheric and Oceanic Sciences (ATOC) is an interdisciplinary program that provides an educational and research environment to examine the dynamical, physical and chemical processes in the atmosphere, ocean and land surface, and the manner in which they interact. A major theme is the establishment of a physical basis for understanding, observing and modeling climate and global change.

Graduate students admitted to ATOC are eligible to receive an advanced degree in atmospheric and oceanic sciences. Graduate students outside of ATOC can pursue the graduate certificate in atmospheric and oceanic sciences while earning a graduate degree from another department at CU Boulder, or while taking coursework as a non-degree-seeking student through Continuing Education's ACCESS Program provided they have already earned a bachelor's degree and meet the course prerequisites. In addition, students inside and outside the department may pursue a graduate certificate in oceanography. For more information on graduate certificate programs, see the Graduate School/Interdisciplinary Programs section.

For more information about ATOC programs and application procedures, call the ATOC office at 303-492-6633 or visit the Atmospheric and Oceanic Sciences (http://www.colorado.edu/atoc/) website.

Course code for this program is ATOC.

Master's Degree

- Atmospheric and Oceanic Sciences - Master of Science (MS) (https://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/atmospheric-oceanic-sciences/atmospheric-oceanic-sciences-master-science-ms/)

Doctoral Degree

- Atmospheric and Oceanic Sciences - Doctor of Philosophy (PhD) (https://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/atmospheric-oceanic-sciences/atmospheric-oceanic-sciences-doctor-philosophy-phd/)

Certificates

- Atmospheric and Oceanic Sciences - Graduate Certificate (https://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/atmospheric-oceanic-sciences/atmospheric-oceanic-sciences-graduate-certificate/)
- Oceanography - Graduate Certificate (https://catalog.colorado.edu/graduate/colleges-schools/arts-sciences/programs-study/atmospheric-oceanic-sciences/oceanography-graduate-certificate/)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Brown, Derek Philip (https://experts.colorado.edu/display/fisid_150027/)
Teaching Assistant Professor; PhD, University of Colorado Boulder

Cassano, John J. (https://experts.colorado.edu/display/fisid_121781/)
Professor; PhD, University of Wyoming

Friedrich, Katja (https://experts.colorado.edu/display/fisid_133607/)
Associate Chair, Professor; PhD, Ludwig-Maximilians-Universität München (Germany)

Han, Weiqing (https://experts.colorado.edu/display/fisid_115493/)
Professor; PhD, Nova University

Jahn Hall, Alexandra (https://experts.colorado.edu/display/fisid_155096/)
Assistant Professor; PhD, McGill University

Karnauskas, Kristopher Benson (https://experts.colorado.edu/display/fisid_155094/)
Associate Professor; PhD, University of Maryland, College Park

Kay, Jennifer E. (https://experts.colorado.edu/display/fisid_153815/)
Associate Professor; PhD, University of Washington

Keen, Richard A.
Instructor Emeritus

Lemone, Margaret Anne
Professor Adjoint

Li, Jianghanyang (https://experts.colorado.edu/display/fisid_169049/)
Assistant Professor; PhD, Purdue University

Lovenduski, Nicole Suzanne (https://experts.colorado.edu/display/fisid_147557/)
Associate Professor; PhD, University of California, Los Angeles

Lundquist, Julie Kay (https://experts.colorado.edu/display/fisid_147838/)
Associate Professor; PhD, University of Colorado Boulder

Moriarty, Julia (https://experts.colorado.edu/display/fisid_165830/)
Assistant Professor; PhD, William & Mary/Virginia Institute of Marine Science

Pilewskie, Peter Andrew (https://experts.colorado.edu/display/fisid_134466/)
Professor; PhD, University of Arizona

Randall, Cora Einterz (https://experts.colorado.edu/display/fisid_102010/)
Distinguished Professor Emeritus; PhD, University of California, Santa Cruz

Sanchez, Sara (https://experts.colorado.edu/display/fisid_167959/)
Assistant Professor; Ph.D., University of California- San Diego

Schmidt, Sebastian (https://experts.colorado.edu/display/fisid_140121/)
Associate Professor; PhD, Leipzig University (Germany)

Toohey, Darin W. (https://experts.colorado.edu/display/fisid_110652/)
Professor; PhD, Harvard University

Toon, Owen Brian (https://experts.colorado.edu/display/fisid_110521/)
Professor; PhD, Cornell University

Wang, Xinyue (https://experts.colorado.edu/display/fisid_173884/)
Assistant Professor; PhD, Purdue University

Weiss, Jeffrey B. (https://experts.colorado.edu/display/fisid_102145/)
Chair, Professor; PhD, University of California, Berkeley

Winters, Andrew (https://experts.colorado.edu/display/fisid_165835/)
Assistant Professor; PhD, University of Wisconsin–Madison

Courses

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.