

DEPARTMENT OF ATMOSPHERIC SCIENCE

About the Department

Our top-rated department focuses on graduate education, cutting-edge research, and public service. We currently have 23 faculty members and approximately 80 graduate students. We also have around 50 full-time researchers and an outstanding and dedicated support staff. Our diverse areas of research (<https://www.atmos.colostate.edu/research/>) include: Cloud Microphysics, Severe Storms and Mesoscale Meteorology; Atmospheric Chemistry and Air Quality; Radiation and Remote Sensing; Climate and Atmosphere-Ocean Dynamics; Global Biogeochemical Cycles and Ecosystems; Data Assimilation, Machine Learning, and Causal Discovery; and Education and Work Force Development. We offer graduate degrees at both the M.S. and Ph.D. levels. Graduate students typically find employment in government research laboratories, academic institutions, the private sector, and military services.

For additional information on graduate programs and the application process, please visit the Department of Atmospheric Science (<https://www.atmos.colostate.edu/>) website, Application Overview (<https://www.atmos.colostate.edu/grad-prog/graduate-program/>), and Atmospheric Science Graduate Student Guide (<https://www.atmos.colostate.edu/documents/GraduateStudentGuide2022.pdf>).

Contact Information

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Undergraduate

No undergraduate major is offered. Undergraduates interested in atmospheric science at the graduate level are encouraged to major in engineering, physics, chemistry, or mathematics.

Graduate

The department offers a Master of Science and a Doctor of Philosophy in Atmospheric Science.

M.S. Program

Students that complete a thesis-based M.S. program acquire the knowledge and proficiency needed in the field of atmospheric science, allowing them to either continue their education at the PhD level, or seek employment in a wide range of careers (such as weather and climate forecasting and prediction, insurance, government labs, NGOs, environmental consulting). Successful students in the M.S. program demonstrate the following (as determined by their committee):

1. Broad knowledge of the fundamental areas of atmospheric science that include Climate and Atmospheric Dynamics, Weather and Weather Systems, Radiation and Remote Sensing, and Atmospheric Chemistry. This knowledge is gained through core curriculum,

electives, weekly cross-disciplinary colloquia, and area-specific group meetings.

2. Understanding and practice of research ethics and broader issues related to social responsibility through a responsible conduct of research course, research projects, and weekly colloquia.
3. Completion of a high-quality original research project.
4. Proficiency in oral and written communication of research through presentations at professional conferences/meetings and preparation of manuscripts for professional journals.

Prerequisites

- Bachelor of Science (B.S.) degree in physics, mathematics, atmospheric science, engineering, chemistry, or related field with a cumulative GPA of at least 3.0
- Calculus-based math course sequence including differential equations and vector analysis
- Calculus-based physics course sequence including kinetics, electricity and magnetism, and some modern topics

Plan A (Thesis)

A minimum of 30 semester credits plus thesis is required. At least 19 credits must be earned in structured academic courses. 11 credits may be in special studies, graduate seminars, and research. Of the total 30 credits, 20 must have the ATS subject code.

All M.S. students must complete the following required courses (required courses account for 13 credit hours):

- ATS 601 Atmospheric Dynamics I (2 credits)
- ATS 606 Introduction to Climate (2 credits)
- ATS 620 Thermodynamics and Cloud Physics (2 credits)
- ATS 621 Atmospheric Chemistry (2 credits)
- ATS 622 Atmospheric Radiation (2 credits)
- ATS 693 Responsible Research in Atmospheric Science (1 credit)
- One of the following:
 - ATS 640 Introduction to Synoptic Dynamics (2 credits)
 - ATS 641 Introduction to Mesoscale Dynamics (2 credits)

All M.S. students must also complete 6 elective credit hours in structured classes. Electives may include any structured class at the 500/600-level. With written advisor approval, electives may also include structured 700-level classes and/or structured graduate courses in other departments. Audited classes do not count towards the M.S. degree.

A student may substitute an alternate course for a required class if:

1. A course similar to the required class has already been completed at the graduate level with a grade of B or higher
2. The student's advisor, the department head, and the instructor of the required course approve the substitution in writing

A student's program of study, and any deviations therein from department degree requirements, requires department head approval.

ATS 784 does not count toward the 19 structured credits. ATS 699A-O and ATS 784 are graded as S/U.

In addition to meeting the formal credit requirements for the M.S. as described above, all graduate students enrolled in the department are

expected to attend the weekly department colloquium series. These colloquia are an important part of the total instructional program. Details can be found on the colloquium page (<http://www.atmos.colostate.edu/colloquia/>) on the ATS website.

Ph.D. Program

The department offers a Ph.D. program for students who want to obtain the highest academic degree available in the field of atmospheric science. Students who earn a Ph.D. must demonstrate significant intellectual achievement, high scholarly ability, and a great breadth of knowledge. Successful students in the Ph.D. program demonstrate the following:

1. Deep knowledge in multiple areas in atmospheric science achieved through elective courses and weekly colloquia.
2. Skillful ability to formulate a science problem, review literature, propose an experiment, and analyze data at a level appropriate for academic or professional success. This ability is assessed through a three-part PhD Preliminary Examination (research prospectus, written exam related to the research/prospectus, and an oral exam by the PhD Committee).
3. Proficiency in (1) written communication through a dissertation and peer-reviewed research articles and (2) oral communication through presentations at professional conferences/meetings.
4. For students interested in gaining teaching experience, acquire basic training in teaching through teaching assistantships and other opportunities.

Prerequisites

- Successful completion of an M.S. degree with thesis in atmospheric science, physics, math, engineering, chemistry, or related field
- Demonstration of aptitude for research

Course Requirements

Ph.D. students must take a minimum of 42 semester credits beyond the (thesis option) master's degree (or 72 semester credits beyond the bachelor's degree). At least 21 credits beyond the master's degree (or 37 credits beyond the bachelor's degree) must be earned in courses numbered 500 or above.

- Ph.D. students are required to take two structured courses per academic year. Students must register for the courses, and only one may be taken as an audit. The structured courses can be selected from the 500, 600, or 700 level. With written advisor approval, the courses may also include structured graduate classes from other departments. When the student is within one semester of graduation, the student and advisor may petition the Department Head, in writing, for a waiver of the "two courses per year" requirement. While ATS 784 (Supervised College Teaching) is not considered a structured academic course, it is allowed to count towards the two courses per academic year Ph.D. requirement.
- Successful completion of ATS 693 (1 cr), Responsible Conduct of Research, offered every spring semester.

In addition to meeting the formal credit requirements for the Ph.D. as described above, all graduate students enrolled in the department are expected to attend the weekly department colloquium series. These colloquia are an important part of the total instructional program. Details

can be found on the colloquium page (<http://www.atmos.colostate.edu/colloquia/>) on the ATS website.

Evaluation Mechanisms

- Successful completion of the department preliminary exam that includes background, methods, and current research that applies to the specific area(s) encompassing the candidate's proposed research topic
- Successful research topic proposal presentation
- Dissertation prepared under the mentorship of the student's advisor and graduate committee that meets the following criteria: displays original and creative scholarship, contributes new knowledge to the field of atmospheric science, and expresses good literate style.
- Successful defense of a dissertation before the student's graduate committee and any other members of the academic and scientific communities who desire to attend

The student's graduate committee is charged with ensuring the student gains breadth in atmospheric science during their tenure in the program. Accordingly, the graduate committee may make recommendations on coursework to be completed prior to graduation.

Courses Atmospheric Science (ATS)

ATS 150 Science of Global Climate Change Credits: 3 (3-0-0)

Course Description: Physical basis of climate change. Energy budget of the earth, the greenhouse effect, carbon cycle, paleoclimate, projections of 21st-century climate.

Prerequisite: None.

Restriction: Must be a: Undergraduate.

Registration Information: Sections may be offered: Online.

Terms Offered: Fall, Spring.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 350 Introduction to Weather and Climate Credits: 2 (2-0-0)

Course Description: Behavior of atmosphere and its influence upon human's activities.

Prerequisite: None.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 351 Introduction to Weather and Climate Lab Credit: 1 (0-3-0)

Course Description: Actual weather data, visualization of meteorological phenomena, in-depth discussion of current environmental issues.

Prerequisite: ATS 350, may be taken concurrently.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 440 Sea Level Rise and a Sustainable Future Credits: 3 (3-0-0)**Also Offered As:** GES 440.**Course Description:** Overview of sea level rise (SLR), with lectures on basic geophysics of SLR, the projected future impacts from climate models, and uncertainty around these projections. Impacts of SLR are discussed in a historical, present, and future context, focusing on social, cultural, economic, and political dimensions.**Prerequisite:** None.**Registration Information:** Completion of AUCC categories 1A, 1B, and 3A. Credit allowed for only one of the following: ATS 440, GES 440, or GES 480A3.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 495 Independent Study Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 543 Global Climate Change Credits: 2 (2-0-0)****Also Offered As:** ESS 543.**Course Description:** Climate change science, climate change impacts, and climate change mitigation, including discussions of current topics in climate change.**Prerequisite:** BZ 300 to 499 or ECOL 300 to 499 or LIFE 300 to 499 or CHEM 300 to 499.**Registration Information:** Sections may be offered: Online. Credit not allowed for both ATS 543 and ESS 543.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 550 Atmospheric Radiation and Remote Sensing Credits: 3 (3-0-0)****Course Description:** Introduction to the role of remote sensing measurements in observing and monitoring land and ocean, atmospheric temperature, humidity, trace gases, aerosols, clouds, and precipitation. Coverage of the fundamentals of atmospheric radiation to explain a variety of remote sensing techniques, and hands-on experience in collecting real-world data to connect satellite remote sensing theory and practice for weather and climate variables.**Prerequisite:** MATH 261 and PH 142.**Registration Information:** Sections may be offered: Online.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 555 Air Pollution Credits: 3 (3-0-0)****Course Description:** Nature, ambient concentrations, sources, sinks, and physiological activities of pollutants; meteorology; legislation; social and economic factors.**Prerequisite:** (CHEM 113) and (MATH 261 or MATH 340) and (PH 122 or PH 142).**Term Offered:** Spring (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 556 Climate Intervention to Cool a Warming Planet Credits: 2 (2-0-0)****Course Description:** Introduction to the climate system and its modification by human activities, different potential climate intervention methods, and the social, legal and political issues salient to the topic.**Prerequisite:** None.**Restriction:** Must not be a: Freshman, Sophomore.**Registration Information:** Junior standing. Completion of AUCC categories 1A, 1B, and 3A. Credit not allowed for both ATS 556 and ATS 580A4.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 560 Air Pollution Measurement Credits: 2 (1-3-0)****Course Description:** Examination and application of techniques for air pollution measurement. Includes sampling and analysis of gases, aerosols, and precipitation.**Prerequisite:** CHEM 114.**Registration Information:** Must register for lecture and laboratory.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 601 Atmospheric Dynamics I Credits: 2 (2-0-0)****Course Description:** Equations of motion; earth's rotation; balanced motion; vorticity and Rossby waves; shallow water models; potential vorticity.**Prerequisite:** (MATH 530) and (MATH 261).**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 602 Atmospheric Dynamics II Credits: 2 (2-0-0)****Course Description:** Sound waves, gravity waves, Rossby waves; numerical weather prediction; baroclinic instability; general circulation; tropical dynamics.**Prerequisite:** ATS 601.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 604 Atmospheric Modeling Credits: 3 (3-0-0)****Course Description:** Design of numerical models of the atmosphere; applications to current problems. Emphasis on practical understanding of relevant numerical methods.**Prerequisite:** ATS 601.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 605 Atmospheric Circulations Credits: 3 (3-0-0)****Course Description:** Observations and theory of the general circulation of the atmosphere, with emphasis on understanding physical mechanisms.**Prerequisite:** ATS 602, may be taken concurrently.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.

ATS 606 Introduction to Climate Credits: 2 (2-0-0)

Course Description: Global energy balance, surface energy balance, the hydrological cycle, atmosphere general circulation, ocean general circulation, climate variability, climate sensitivity and feedbacks.

Prerequisite: (MATH 530) and (MATH 261).

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 607 Computational Methods for Atmospheric Science Credits: 3 (3-0-0)

Course Description: Computer programming tools unique to and common in the atmospheric sciences.

Prerequisite: ATS 601, may be taken concurrently.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 610 Physical Oceanography Credits: 3 (3-0-0)

Course Description: Foundations of ocean circulation theory and the general circulation of the oceans using observational data and rotating tank experiments.

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 620 Thermodynamics and Cloud Physics Credits: 2 (2-0-0)

Course Description: Equilibrium thermodynamics, cloud microphysics, precipitation formation, and cloud electrification.

Prerequisite: MATH 340 and PH 142.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 621 Atmospheric Chemistry Credits: 2 (2-0-0)

Course Description: Overview of chemical kinetics and equilibria; sources and sinks of pollutants; photochemistry and smog formation; aqueous-phase chemistry; acid rain.

Prerequisite: CHEM 114 and MATH 340 and PH 142.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 622 Atmospheric Radiation Credits: 2 (2-0-0)

Course Description: Role of radiation in the energy balance of the climate system; Absorption and scattering of solar radiation; Emission and absorption of terrestrial radiation; Interactions of radiation with clouds and aerosols; Role of radiative active trace gases.

Prerequisite: ATS 620.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 623 Atmospheric Boundary Layer Credits: 2 (2-0-0)

Course Description: Equations for shallow atmospheric motions; thermal instability of a fluid layer; atmospheric turbulence; flow stability; 1-D mixed layer models.

Prerequisite: ATS 601, may be taken concurrently.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall (even years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 631 Introduction to Atmospheric Aerosols Credits: 2 (1-3-0)

Course Description: Physical, chemical and microphysical characteristics of atmospheric particulate matter; measurement principles and techniques.

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 632 Interpreting Satellite Observations Credits: 2 (1-3-0)

Course Description: Broad theoretical and practical overview of satellite observations of atmospheric composition. Introduction to the theoretical foundations of satellite composition retrievals of both gases and aerosols, and the associated strengths and weaknesses of commonly used atmospheric products.

Prerequisite: ATS 621 and ATS 622.

Restriction: Must be a: Graduate, Professional.

Registration Information: Must register for lecture and laboratory. Credit not allowed for both ATS 632 and ATS 681A1.

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 640 Synoptic Meteorology Credits: 2 (1-2-0)

Course Description: Synoptic-scale weather systems; thermodynamic diagrams; vertical motion; fronts; cyclones and anticyclones.

Prerequisite: ATS 601, may be taken concurrently.

Restriction: Must be a: Graduate, Professional.

Registration Information: Must register for lecture and laboratory.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 641 Mesoscale Meteorology Credits: 2 (1-2-0)

Course Description: Mesoscale weather systems; instabilities; orographic flows; dynamics of convective storms; organized convection.

Prerequisite: ATS 640.

Restriction: Must be a: Graduate, Professional.

Registration Information: Must register for lecture and laboratory.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 650 Measurement Systems and Theory Credits: 2 (2-0-0)

Course Description: Surface and upper air measurement systems; theory and system response, sensor design; automated data collection, analysis and display systems.

Prerequisite: PH 142 and STAT 301.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 651 Data Assimilation in Numerical Models Credits: 3 (3-0-0)

Course Description: Methods for combining theoretical understanding encoded in complex weather and climate models with real-world observations. Applications include weather prediction and other problems in the geosciences.

Prerequisite: (MATH 530) and (MATH 340 and STAT 301).

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 652 Atmospheric Remote Sensing Credits: 2 (2-0-0)

Course Description: Concepts of electromagnetic and acoustic wave propagation; active and passive remote sensing techniques including radar, lidar, thermal emission systems.

Prerequisite: ATS 622.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 655 Objective Analysis in Atmospheric Sciences Credits: 3 (3-0-0)

Course Description: Objective analysis of geophysical data: general statistics; matrix methods; time series analysis. Emphasis on applications to real-world data.

Prerequisite: ATS 601 or MATH 530.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 660 Social Responsibility in Atmospheric Science Credits: 2 (2-0-0)

Course Description: Structure and resources for preparation in addressing issues of participation, representation, and inclusion challenges that are unique to the field of atmospheric science. A diversity of scholarship to develop a robust understanding of foundational concepts and practices for personal and social change and incorporate and disseminate these concepts through atmospheric science research.

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Registration Information: Credit not allowed for both ATS 660 and ATS 680A3.

Term Offered: Fall (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 693 Responsible Research in Atmospheric Science Credit: 1 (0-0-1)

Course Description: Scientific misconduct; ethical publishing; record keeping; data management; professional skills applicable to atmospheric science.

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Registration Information: Must be admitted to Atmospheric Science degree program.

Term Offered: Spring.

Grade Mode: S/U Sat/Unsat Only.

Special Course Fee: No.

ATS 695A Independent Study: Atmosphere/Ocean Coupling Credits: Var[1-18] (0-0-0)

Course Description:

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

ATS 695B Independent Study: Atmospheric Science Topics Credits: Var[1-18] (0-0-0)

Course Description:

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

ATS 699A Thesis: Global Climate Change Credits: Var[1-18] (0-0-0)

Course Description:

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

ATS 699B Thesis: Land-Atmosphere Interactions Credits: Var[1-18] (0-0-0)

Course Description:

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

ATS 699C Thesis: Tropical Meteorology Credits: Var[1-18] (0-0-0)

Course Description:

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Terms Offered: Fall, Spring, Summer.

Grade Mode: S/U Sat/Unsat Only.

Special Course Fee: No.

ATS 699D Thesis: Weather Systems Credits: Var[1-18] (0-0-0)

Course Description:

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

ATS 699E Thesis: Remote Sensing Credits: Var[1-18] (0-0-0)

Course Description:

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Terms Offered: Fall, Spring, Summer.

Grade Mode: Instructor Option.

Special Course Fee: No.

ATS 699F Thesis: Ocean-Atmosphere Interactions Credits:**Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699G Thesis: General Circulation Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699H Thesis: Remote Sensing of Climate Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699I Thesis: Atmospheric Chemistry Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699J Thesis: Aerosol and Cloud Microphysics Credits:****Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699K Thesis: Dynamic Meteorology Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699L Thesis: Data Assimilation and Causality Credits:****Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** S/U Sat/Unsat Only.**Special Course Fee:** No.**ATS 699M Thesis: Mesoscale Meteorology Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699N Thesis: Dynamics and Physics of Clouds Credits:****Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699O Thesis: Mesoscale Modeling Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699P Thesis: Radiation Transfer Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** S/U Sat/Unsat Only.**Special Course Fee:** No.**ATS 699Q Thesis: Radar Meteorology Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699R Thesis: Aerosol and Cloud Chemistry Credits:****Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699S Thesis: Climate Dynamics Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 699T Thesis: Climate Analysis Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** S/U Sat/Unsat Only.**Special Course Fee:** No.**ATS 699U Thesis: Tropospheric Chemistry Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.

ATS 699V Thesis: Atmospheric Variability Credits: Var[1-18] (0-0-0)**Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 703 Numerical Weather Prediction Credits: 2 (2-0-0)****Course Description:** Quasi-geostrophic approximation; barotropic, baroclinic, primitive equation, and general circulation models; numerical methods.**Prerequisite:** ATS 602.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (even years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 704 Large-Scale Atmospheric Dynamics Credits: 2 (2-0-0)****Course Description:** Quasi-static, quasi-geostrophic equations; planetary waves; geostrophic adjustment; barotropic, baroclinic instability; frontogenesis; tropical cyclones.**Prerequisite:** ATS 602.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 707 Atmospheric Waves and Vortices Credits: 3 (2-0-1)****Course Description:** Atmospheric wave motions and embedded vortices spanning mountain waves to large-scale Rossby waves and critical layers.**Prerequisite:** ATS 605.**Restriction:** Must be a: Graduate, Professional.**Registration Information:** Must register for lecture and recitation.**Term Offered:** Fall (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 708 Middle Atmospheric Dynamics Credits: 3 (3-0-0)****Course Description:** Dynamics of the stratosphere and mesosphere with emphasis on the lower and middle stratosphere.**Prerequisite:** ATS 602.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 710 Geophysical Vortices Credits: 3 (3-0-0)****Course Description:** Observational, experimental, and theoretical aspects of geophysical vortices, such as hurricanes, polar lows, tornadoes, and dust devils.**Prerequisite:** ATS 602.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (even years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 711 Microclimate Credits: 2 (2-0-0)****Course Description:** Momentum, heat, water, and trace gas fluxes near the earth's surface, including fluxes between the atmosphere and the land/ocean/ice surfaces.**Prerequisite:** (ATS 623) and (MATH 340).**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (even years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 712 Dynamics of Clouds Credits: 3 (3-0-0)****Course Description:** General theory of cloud dynamics; parameterization of microphysics and radiation; models of fog, stratocumuli, cumulonimbi, and orographic clouds.**Prerequisite:** ATS 623.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Spring (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 715 Atmospheric Oxidation Processes Credits: 2 (2-0-0)****Course Description:** Atmospheric hydrocarbon and nitrogen oxide reactions; aqueous phase scavenging and reactions; chemical pathways in the atmosphere.**Prerequisite:** ATS 621.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 716 Air Quality Characterization Credits: 2 (1-2-0)****Course Description:** Planning, executing, and reporting on a measurement campaign to characterize local air quality.**Prerequisite:** (ATS 560) and (ATS 555 or ATS 621).**Restriction:** Must be a: Graduate, Professional.**Registration Information:** Must register for lecture and laboratory.**Term Offered:** Spring.**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 721 Theoretical Topics in Radiative Transfer Credits: 3 (3-0-0)****Course Description:** Physics of atmospheric radiation; theoretical techniques used to show radiation transfer equation.**Prerequisite:** ATS 622.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 722 Atmospheric Radiation and Energetics Credits: 3 (2-0-1)****Course Description:** Radiative transfer in the atmosphere; implications on remote sensing and energetics.**Prerequisite:** ATS 622.**Restriction:** Must be a: Graduate, Professional.**Registration Information:** Must register for lecture and recitation.**Term Offered:** Spring (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.

ATS 724 Cloud Microphysics Credits: 2 (2-0-0)

Course Description: Theories and observations of nucleation; cloud droplet spectra broadening; precipitation growth and breakup; ice multiplication; cloud electrification.

Prerequisite: ATS 621.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 730 Mesoscale Modeling Credits: 3 (3-0-0)

Course Description: Development of basic equations used in mesoscale models and methodology of solution

Prerequisite: ATS 602 and ATS 623.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall (even years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 735 Mesoscale Dynamics Credits: 3 (3-0-0)

Course Description: Analysis of physical and dynamical processes that initiate, maintain, and modulate atmospheric mesoscale phenomena.

Prerequisite: ATS 602.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 737 Satellite Observation of Atmosphere and Earth Credits: 3 (3-0-0)

Course Description: Satellite measurements; basic orbits and observing systems; applications of remote probing and imaging to investigations of atmospheric processes.

Prerequisite: ATS 622 and ATS 652.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring (even years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 740 Atmospheric Electricity Credits: 2 (2-0-0)

Course Description: Foundations of atmospheric electricity, including global electric circuit and the role of thunderstorms in maintaining this circuit, thunderstorm electrification processes based on non-inductive charging theory, lightning detection based on RF and optical sensing, and lightning phenomena including Transient Luminous Events.

Prerequisite: ATS 620.

Restriction: Must be a: Graduate, Professional.

Registration Information: Written consent of instructor. Credit not allowed for both ATS 740 and ATS 780A3.

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 741 Radar Meteorology Credits: 3 (3-0-0)

Course Description: Radar systems; radar equation and applications; multiple Doppler observation and processing; radar studies of mesoscale systems.

Prerequisite: ATS 652.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 742 Tropical Meteorology Credits: 2 (2-0-0)

Course Description: Overview of the tropical atmosphere, monsoons, intraseasonal variability, hurricanes, theory of tropical convection and the large-scale circulation.

Prerequisite: ATS 601 and ATS 602 and ATS 606.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring (even years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 743 Interactions of the Ocean and Atmosphere Credits: 3 (3-0-0)

Course Description: Ocean-atmosphere interactions in observations, theory, and models. Time mean atmosphere-ocean circulations through climate variability and change.

Prerequisite: ATS 602.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring (odd years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 745 Atmospheric General Circulation Modeling Credits: 3 (3-0-0)

Course Description: Current problems in modeling of the general circulation of the atmosphere.

Prerequisite: ATS 602 and ATS 605.

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring (even years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 750 Climate Dynamics: Atmospheric Variability Credits: 3 (3-0-0)

Course Description: Analysis and interpretation of large-scale patterns of climate variability and observed climate change.

Prerequisite: ATS 605 and ATS 655.

Restriction: Must be a: Graduate, Professional.

Term Offered: Fall (even years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 752 Inverse Methods in Atmospheric Science Credits: 2 (2-0-0)

Course Description: Introduction to inverse modeling, with particular application to remote sensing retrievals, flux inversions and data assimilation.

Prerequisite: None.

Restriction: Must be a: Graduate, Professional.

Registration Information: Ph.D. standing in Atmospheric Science required.

Term Offered: Fall.

Grade Mode: Traditional.

Special Course Fee: No.

ATS 753 Global Hydrologic Cycle Credits: 3 (3-0-0)

Course Description: Hydrologic cycle, moisture transport and air-ground exchange; water budgets of meteorological phenomena; climatology of atmospheric water.

Prerequisite: (ATS 601) and (ATS 622 or ATS 652).

Restriction: Must be a: Graduate, Professional.

Term Offered: Spring (even years).

Grade Mode: Traditional.

Special Course Fee: No.

ATS 755 Theoretical and Applied Climatology Credits: 3 (3-0-0)**Course Description:** Current topics in climate research.**Prerequisite:** ATS 606.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (even years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 760 Global Carbon Cycle Credits: 2 (2-0-0)****Course Description:** Exchanges of CO₂ between the atmosphere, the land surface, and oceans. Biogeochemical processes. Micrometeorological and inverse flux estimation.**Prerequisite:** ATS 606.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Spring (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 761 Land-Atmosphere Interactions Credits: 2 (2-0-0)****Course Description:** Exchange of energy, water, momentum, and carbon between the land surface and the atmosphere.**Prerequisite:** ATS 606.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (even years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 762 Biosphere-Chemistry-Climate Interactions Credits: 2 (2-0-0)****Course Description:** Explore the sensitivity of the climate system to atmospheric chemical composition with emphasis on connections to biospheric processes and feedbacks.**Prerequisite:** ATS 621.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Spring (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 765 Climate Dynamics-Ocean Variability Credits: 3 (3-0-0)****Course Description:** Climate variability on time scales of years to millennia with focus on the role of the ocean circulation. Approach through dynamical systems theory.**Prerequisite:** ATS 606.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (even years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 770 Ocean Modeling Credits: 3 (3-0-0)****Course Description:** Conceptual and numerical ocean models and their application to current problems in climate science and biogeochemical cycles.**Prerequisite:** ATS 601.**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (even years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 772 Aerosol Physics, Chemistry, Clouds & Climate Credits: 3 (3-0-0)****Course Description:** The physics and chemistry of atmospheric aerosols including composition, size, and interaction with radiation and clouds, including the development of research-grade models of aerosols, clouds, and radiation.**Prerequisite:** (CHEM 114 and MATH 161) and (PH 122 or PH 142).**Restriction:** Must be a: Graduate, Professional.**Term Offered:** Fall (odd years).**Grade Mode:** Traditional.**Special Course Fee:** No.**ATS 784 Supervised College Teaching Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 786 Practicum Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 795 Independent Study Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 796 Group Study Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799A Dissertation: Global Climate Change Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799B Dissertation: Land-Atmosphere Interactions Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.

ATS 799C Dissertation: Tropical Meteorology Credits: Var[1-18] (0-0-0)**Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799D Dissertation: Weather Systems Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799E Dissertation: Remote Sensing Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799F Dissertation: Ocean-Atmosphere Interactions Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799G Dissertation: General Circulation Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799H Dissertation: Remote Sensing of Climate Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799I Dissertation: Atmospheric Chemistry Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799J Dissertation: Aerosol and Cloud Microphysics Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799K Dissertation: Dynamic Meteorology Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799L Dissertation: Data Assimilation and Causality Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799M Dissertation: Mesoscale Meteorology Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799N Dissertation: Dynamics and Physics of Clouds Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799O Dissertation: Mesoscale Modeling Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799P Dissertation: Radiation Transfer Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799Q Dissertation: Radar Meteorology Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.

ATS 799R Dissertation: Aerosol and Cloud Chemistry Credits:**Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799S Dissertation: Climate Dynamics Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799T Dissertation: Climate Analysis Credits: Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** S/U Sat/Unsat Only.**Special Course Fee:** No.**ATS 799U Dissertation: Tropospheric Chemistry Credits:****Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.**ATS 799V Dissertation: Atmospheric Variability Credits:****Var[1-18] (0-0-0)****Course Description:****Prerequisite:** None.**Restriction:** Must be a: Graduate, Professional.**Terms Offered:** Fall, Spring, Summer.**Grade Mode:** Instructor Option.**Special Course Fee:** No.