Atmospheric Science

National Space Science and Technology Center
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Department Chair: Larry Carey, Associate Professor

The Atmospheric Science department offers the following graduate degree programs:

- Master of Science - Atmospheric Science
- Master of Science - Earth Systems Science
- Doctor of Philosophy - Atmospheric Science
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Admission Requirements

Refer to the appropriate section of the Graduate Catalog for general admission and degree requirements. The applicant should have training through a calculus sequence (including the calculus of vector-valued functions), a course in linear algebra, and courses in ordinary and partial differential equations. He or she should also have completed at least two semesters of chemistry, two semesters of calculus-based physics, and have demonstrable computer proficiency in at least one high-level programming language.

Program Objective

The Atmospheric Science Department's first objective is to produce graduates who are successful in writing scientific research papers in peer-reviewed scientific journals and in making presentations at national or international scientific conferences and workshops. Our second objective is to produce graduates who successfully obtain employment as research scientists in a research center, government lab, or corporation, or in academic positions at a university.

Learning Outcomes

Students will demonstrate:

- Knowledge of the reviewed literature in the atmospheric science that is relevant to their specific research
- Proficiency in scientific methodology, while successfully carrying out a research project from concept to completion
- Effective oral communication skills in reporting the results of their scientific research

Master's Program in Atmospheric Science

http://nsstc.uah.edu/ats/ats_ms.html

- To obtain the M.S. degree in Atmospheric Science, each student must satisfy all requirements of the School of Graduate Studies, as well as those of the Atmospheric Science Program.
- Students must formulate an appropriate Program of Study (POS), in consultation with a faculty advisor and chair, **before the end of the second semester**.
- Students must maintain a cumulative GPA of at least 3.0.

Option 1 - Thesis

Minimum degree requirements under this plan include completion of at least 24 credit hours of graduate course work and at least 6 credit hours of thesis research. At least 50% of the required 24 semester hours must be from 600 level (or higher) courses. Students are also required to take 6 credit hours of supporting courses. The supporting courses do not count toward the minimum degree requirements.

Required Core Courses [1,2]		
ATS 541	ATM THERMODYN & CLOUD PHYSICS	3
ATS 551	ATMOS FLUID DYNAMICS I	3
ATS 561	ATMOSPHERIC RADIATION I	3
Elective Courses		
Select 12 semester hours from 600 level (or higher) courses		12

Select 3 semester hours from 500 or 600 level courses and may be outside of ATS only with advisor's approval		3
Required Supporting Courses		
ATS 509	APPL COMPUTERS IN METEOROLOGY [3]	3
ATS 780	ATMOSPHERIC SCIENCE SEMINAR	1
ATS 781	STUDENT SEMINAR	1
ATS 782	PROFESSIONAL DEVELOPMENT	1
Thesis Credits		
ATS 699	MASTER'S THESIS	6
Total Semester Hours		**36**

1. Students must earn a B or above in core courses.
2. Students who have earned a B or better in the undergraduate equivalent ATS 541, ATS 551, ATS 561 at UAH do not have to re-take the course at the graduate level. However, their Program of Study must include alternative semester hours at the appropriate level approved by their advisor and chair of the department.
3. Students who have earned a B or better in the undergraduate equivalent of ATS 509 at UAH have fulfilled the requirement.

Additional Information

In Option 1, the student must write and defend a thesis. The thesis must show evidence of the student's capability for research, independent thought, and analysis in Atmospheric Science and must be written in fluent, acceptable english. During the second semester, the student, with the guidance of their advisor, should form a supervisory committee. Students must submit a 5 page thesis proposal to be approved by the advisor and committee by the **end of the third full semester.**

Option 2 - Non-Thesis

Minimum degree requirements under this plan include completion of at least 33 credit hours of graduate course work. At least 50% of the required 33 semester hours must be from 600 level (or higher) courses. In addition, all M.S. students are required to take 6 credit hours of supporting courses. The supporting courses do not count toward the minimum degree requirements.

Required Core Courses [1,2]		
ATS 541	ATM THERMODYN & CLOUD PHYSICS	3
ATS 551	ATMOS FLUID DYNAMICS I	3
ATS 561	ATMOSPHERIC RADIATION I	3
Elective Courses		
Select 18 semester hours from 600 level (or higher) courses		18
Select 6 semester hours from 500 or 600 level courses and may be outside of ATS only with advisor's approval		6
Required Supporting Courses		
ATS 509	APPL COMPUTERS IN METEOROLOGY [3]	3
ATS 780	ATMOSPHERIC SCIENCE SEMINAR	1
ATS 781	STUDENT SEMINAR	1
ATS 782	PROFESSIONAL DEVELOPMENT	1
Total Semester Hours		**39**

1. Students must earn a B or above in core courses.
2. Students who have earned a B or better in the undergraduate equivalent ATS 541, ATS 551, ATS 561 at UAH do not have to re-take the course at the graduate level. However, their Program of Study must include alternative semester hours at the appropriate level approved by their advisor and chair of the department.
3. Students who have earned a B or better in the undergraduate equivalent of ATS 509 at UAH have fulfilled the requirement.

Comprehensive Examination/Thesis Defense

A final comprehensive examination is required of all candidates for a master's degree; this examination may be written or oral, or both. In accordance with the Graduate Studies Dates & Deadlines, a written notice of the time and place of the examination/defense must be sent to the Graduate Dean. After approval by the Graduate Dean, the Department Chair sends a copy of the written *Notification of Oral Examination/Defense* to the candidate and each member of the committee. A student may take the Comprehensive Examination only twice.

- **Thesis** candidates will be examined *primarily* on the thesis by a committee of at least three faculty members appointed by the Department Chair and approved by the Graduate Dean.
- **Non-Thesis** candidates will be examined on course work. Three weeks before the exam, the advisor/chair will email two "lead-in" questions about the student's course work from each committee member. This will be the starting point for the oral exam. The committee members may also question further during the exam. Students who pass all sections of the Ph.D. Preliminary Exam are not required to take the M.S. Comprehensive Exam.

M.S. Supervisory Committee

The committee must consist of a minimum of three members and be approved by the Department Chair. Two of the three members, including the Committee Chair, must be full-time, tenured, or tenure-earning faculty members in the department. The other member may be nominated to the Affiliate Graduate Faculty or be a current faculty member from another UAH department.

Paperwork

- Students must formulate an appropriate Program of Study (POS), in consultation with a faculty advisor and chair, before the end of the second semester.
- Application for graduate degree according to the Graduate Studies *Dates & Deadlines*.
- Notification of Oral Examination/Defense according to the Graduate Studies *Dates & Deadlines*.

Doctoral Program in Atmospheric Sciences

http://nsstc.uah.edu/ats/ats_phd.html

The doctor of philosophy degree is a research-oriented degree awarded upon the demonstration of scholarly competence. To obtain the Ph.D. degree in Atmospheric Science, each student must satisfy all requirements of the School of Graduate Studies, as well as those of the Atmospheric Science Program. Admission to the Ph.D. program in Atmospheric Science is dependent upon satisfactory performance on the Preliminary Examination, which is administered twice a year. Students entering UAH with an M.S. degree or previous graduate training in Atmospheric Science must pass the Preliminary Examination at an early opportunity. Students are permitted two attempts to pass the Preliminary Examination.

In summary, the five major requirements for the Ph.D. degree in Atmospheric Science are the following:

1. Take the core courses and pass the preliminary examination

Each student must pass the **Preliminary Examination** covering material in the three core courses plus three other ATS courses as outlined in the Ph.D. Preliminary Exam policies. The core courses are:

ATS 541	ATM THERMODYN & CLOUD PHYSICS	3
ATS 551	ATMOS FLUID DYNAMICS I	3
ATS 561	ATMOSPHERIC RADIATION I	3

It is anticipated that a student will take the exam during the second year of graduate study, but those with a strong background in Atmospheric Science may take the exam within the first year. The Preliminary Examination may be taken only twice. The student must pass all six sections in order to continue toward Ph.D. candidacy.

Supervisory Committee

After a student has passed the Preliminary Examination, a Supervisory Committee will be formed. The committee will consist of the student’s academic advisor plus at least four other members. Three of the Committee Members, including the Committee Chair, must be tenured or tenure-track members of the ATS faculty. The committee must be approved by the Graduate Dean. The committee will later administer the Qualifying Examination, and with consent of the Graduate Dean, give approval to all aspects of requirements 2-5.

2. Satisfy the residence requirement

According to graduate school policy, residence may be established through either:

1. being enrolled as a full-time student (at least 9 graduate semester hours) either for one continuous academic year, or for Spring and Fall semesters in the same calendar year, or
2. being enrolled in at least 6 semester hours of graduate course work in at least three of four consecutive semesters.

3. Complete an acceptable Program of Study (POS).

Students must formulate an appropriate Program of Study, in consultation with a faculty advisor and chair, before the end of the second semester**.** Each Program of Study, individualized to meet the student's needs and requirements of the program, will stress breadth, depth, and research competence, and relate the major area to its applications. Any prerequisites for courses on the POS must be fulfilled before attempting the courses.

- Minimum degree requirements of this Program of Study will include at least 48 semester hours of graduate level **course work**. These include the core courses needed to prepare for the Preliminary Examination and courses required in a major area of concentration that will prepare the student to conduct original research. While required, supporting courses, ATS 509 (http://catalog.uah.edu/search/?P=ATS%20509), ATS 780 (http://catalog.uah.edu/search/?P=ATS%20780), ATS 781 (http://catalog.uah.edu/search/?P=ATS%20781), ATS 782 (http://catalog.uah.edu/search/?P=ATS%20782), are not included in the minimum degree requirements of 48 semester hours.
- Students can transfer up to 24 semester hours of **course work** from their M.S. program.
- Students can transfer an additional 6 semester hours of **course work,** including, with approval, special topics courses, but **not** including thesis semester hours.
- 50% of the minimum degree requirements (48 semester hours) must be from 600 level or higher courses.
- A minimum of 18 semester hours of doctoral dissertation (ATS 799 (http://catalog.uah.edu/search/?P=ATS%20799)) is required.
- Students must register for a total of 3 semester hours of Seminar and Professional Development. (ATS 780 (http://catalog.uah.edu/search/?P=ATS%20780), ATS 781 (http://catalog.uah.edu/search/?P=ATS%20781), ATS 782 (http://catalog.uah.edu/search/?P=ATS%20782))
- Students must maintain a cumulative GPA of at least 3.0.

4. Pass the Qualifying Examination

Once the Program of Study has been submitted and the Ph.D. Student Advisory Committee (SAC) has been formed, the next steps are to submit a written dissertation proposal to the SAC and then make an oral presentation (usually 2-3 weeks later). This will be followed by the Qualifying Examination, which will cover the major areas of study and the student's proposal for the dissertation topic. It will have both written and oral components and will be prepared and graded by the SAC. This examination may be taken at most twice.

5. Complete and defend a research dissertation

Each student must complete and successfully defend a research dissertation, the results of which are publishable in a nationally recognized journal. The dissertation, which must comply with the regulations set forth in the School of Graduate Studies' Thesis and Dissertation Manual, must be approved by the student's supervisory committee, the chair of the Atmospheric Science Department, the Dean of the College of Science, and the Dean of the School of Graduate Studies. A significant portion of the dissertation must be submitted for publication in an approved journal.

Additional Information

All requirements for the Ph.D. must be completed in no more than five years after the student has passed the qualifying examination.

The atmospheric science program does not require knowledge of a foreign language, but it does require proficiency in both spoken and written english.

ATS 501 - SURVEY OF ATMOSPHERIC SCIENCE
Semester Hours: 3

General survey of the field of atmospheric science includes thermodynamics, atmospheric dynamics, cloud physics, and atmospheric radition. Quantitative examination of atmospheric properties including atmospheric composition, structure and dynamics.

ATS 509 - APPL COMPUTERS IN METEOROLOGY
Semester Hours: 3

Survey of scientific programming techniques used in atmospheric sciences. Various data types, control statements, and programming design using object oriented techniques are discussed, emphasizing efficient programming. Course prepares students for graduate work and research in atmospheric science.

ATS 510 - OPERATIONAL WEATHER FORECAST'G
Semester Hours: 3

Subjective & objective methods of atmospheric prognosis. Forecasting critical weather elements. Interpretation, use & systematic errors of computer-generated products, human factors, & application of meteorological theory in an operational setting.

ATS 513 - GIS & REMOTE SENSING
Semester Hours: 3

Hands-on approach to GIS and satellite remote sensing. Popular satellite data sets such as LANDSAT and AVHRR are coupled with GIS data sets to increase understanding of the earth system. Topics include satellite sensors, basic radiative transfer, orbits, raster formats, atmospheric correction, distortion, image corrections, rotations and mapping, spatial resolution, image interpretation, radiometric and geometric enhancement, multispectral transformations, and classifications. (Same as ATS 413, ES 413, ES 513.) Spring.

ATS 515 - ADVANCED TOPICS IN GIS
Semester Hours: 3

Advanced special topics: visualization of GIS and remote sensing data, landscape characterization (pattern vs. process), multitemporal analysis, aggregation of data types, developing an integrated GIS environment for performing complex space-time modeling analyses, and land-atmosphere interactions. (Same as ATS 415, ES 415, ES 515.) Spring.

ATS 520 - INTRO ATMOS CHEM & AIR POLLUTI
Semester Hours: 3

An introduction designed to provide students with the basics of atmospheric chemistry and air pollution concepts. Topics include air pollutants, air-pollution meteorology, atmospheric gases and aerosols, and atmospheric processes.

ATS 522 - AIR POLLU:METEOROLOGY CONCEPTS
Semester Hours: 3

ATS 541 - ATM THERMODYN & CLOUD PHYSICS
Semester Hours: 3

Thermodynamic & cloud physical processes in the atmosphere. Atmospheric statics & stability. Role of aerosols in nucleation of cloud and ice particles. Physical processes that produce the growth of hydrometeors in cold and warm clouds. Applicable measurement techniques.

ATS 551 - ATMOS FLUID DYNAMICS I
Semester Hours: 3

Fluid dynamics in the atmosphere. Coriolis acceleration, scale analysis and appropriate approximations of the complete governing equations. Numerical analysis and interpretation of weather phenomena.

ATS 553 - ATS RADIATN/REMOTE SENSING
Semester Hours: 3

ATS 554 - FORECASTING MESOSCALE PROC
Semester Hours: 3

Detection and forecasting of atmospheric mesoscale phenomena including the structure and evoluation of clouds, precipitation (including floods) thunderstorms and severe weather. Includes basics of instruments used to detect mesoscale phenomena, most notably satellite and radar. Prerequisites: ATS 551.

ATS 561 - ATMOSPHERIC RADIATION I
Semester Hours: 3

Fundamentals of terrestrial atmospheric radiation. Topics include: basic concepts, radiative transfer equation, gaseous absorption, scattering by molecules and particles, band models, transmittance along an inhomogeneous path.

ATS 571 - INTRO TO RADAR METEOROLOGY
Semester Hours: 3

Introduction to principles of radar meteorology, including radar operations, hardware, interpretation and analysis. Doppler, dual-polarization and dual-wavelength radar theory, methods and applications are covered. Prerequisite: ATS 541.

ATS 581 - ATS THERMODYNAMICS & CHEM
Semester Hours: 3

ATS 590 - SPECIAL TOPICS
Semester Hours: 1-3

Selected topics of interest not included in other courses.

ATS 603 - CLIMATE DYNAMICS
Semester Hours: 3

Origin and evolution of the climate system including underlying causes for past climates such as occurred during the ice ages. Statistical processing of various time series to extract climactic signals in the data. Determination of global-scale forcing mechanisms, which impact climate. Prerequisites: ATS 541 and ATS 551.

ATS 606 - DATA ANALY ATMOSPHERIC SCNTS
Semester Hours: 3

A theoretical and practical introduction to various data analysis methods commonly used in atmospheric science. Topics include forecasting techniques to generate models to fit data, assess models using parametric tests, probability theory and Monte Carlo methods to solve a variety of problems. Prerequisites: ATS 509.

ATS 620 - ATMOSPHERIC CHEMISTRY & AEROSI
Semester Hours: 3

Primary processes, thermodynamics, photochemistry, kinetics, models, and measurements applied to troposphere and stratosphere; natural and anthropogenic; chlorine, nitrogen, hydrogen, and oxygen catalytic cycles; ground- and satellite-based observations of trace species. Prerequisites: ATS 520.

ATS 622 - AIR POLLUTION MODELING
Semester Hours: 3

Air pollution Langrangian and Eulerian modeling concepts and methods from micro to synoptic scales; plume, large eddy simulations and urban-regional models in research and regulatory applications; transport, dispersion, chemistry, clouds, aerosols, and wet/dry deposition. Prerequisites: ATS 520 and ATS 551.

ATS 630 - PHYSICAL CLIMATOLOGY
Semester Hours: 3

This course examines the physical aspects of the global climate system, including the global energy balance, surface energy balance, hydrologic cycle, climate classification, ocean change and other selected topics such as climate sensitivity. Prerequisites: ATS 501 or 541.

ATS 635 - GENERAL CIRCULATION
Semester Hours: 3

Detailed examination of the observed dynamic, thermodynamic and chemical structure of the atmosphere, including mid-latitude baroclinic systems, tropical systems, global-scale energy, mass and momentum budgets and the fundamental climatology of the atmosphere. Prerequisites: ATS 541 and ATS 551.

ATS 642 - PRECIP PHYSICS FOR RADAR
Semester Hours: 3

Cloud mirophyics theory, models, in-situ and radar observations of hydrometers will be utilized together to explore advanced concepts in precipitation physics and their connection to radar meteorology, including coalescense, break-up, freezing, size sorting, aggregation, riming and melting.

ATS 651 - ATMOS FLUID DYNAMICS II
Semester Hours: 3

Wave motions in the atmosphere with emphasis of Rossby, Kelvin and gravity waves. Systematic scaling of primitive equations to develop quasi-geostrophic and Elkman-layer theory. Shallow water theory, stratified flows, and baratropic and baraclinic instability. Prerequisites: ATS 551.

ATS 652 - ADV SYNOPTIC METEOROLOGY
Semester Hours: 3

Analysis, interpretation and forecasting synoptic-scale and mesoscale phenomena, including air masses, frontal systems, cyclones, anti-cyclones and waves toward understanding process dynamics. Emphasize the use of observational, satellite and numerical model data, including radars and profilers. Prerequisites: ATS 541 and ATS 551.

ATS 654 - FORECASTING MESOSCALE PROCESSE
Semester Hours: 3

ATS 655 - BOUNDARY LAYER METEOROLOGY
Semester Hours: 3

Survey of atmospheric boundary layer (ABL) properties. Review of turbulence, convective and stable boundary layers, surface forcing, boundary layer discontinuties, and singular phenomena within the ABL. Atmospheric field measurements are used to enhance understanding of ABL process. Prerequisites: ATS 541 and ATS 551.

ATS 656 - TROPICAL METEOROLOGY
Semester Hours: 3

Overview concepts of the dynamics and climatology of the tropics and of significant tropical precipitation systems. Topics also include Kelvin waves, equatorial flows, convective scale dynamics, island meteorology, tropical cyclones, ENSO, radiative-convective equilibrium, gregarious cloud systems. Prerequisites: ATS 541 and ATS 551.

ATS 657 - NOWCASTING THEORY METHODS
Semester Hours: 3

Theory, methods and applications of 0-6 hour weather and ecological prediction, which is a forecast time period when numerical prediction models have low skill. Topics include predictability, data assimilation, statistical methods, and algorithms using Earth and atmospheric science observations.

ATS 670 - SATELLITE REMOTE SENSING I
Semester Hours: 3

Using a hands-on approach, this course covers a broad range of topics concerning digital image processing applied to the remote sensing of atmospheric, cloud and surface properties using various satellite data sets. Prerequisites: ATS 509.

ATS 671 - GROUND BASED REMOTE SENSING
Semester Hours: 3

Principles and measurement capabilities of active and passive ground-based remote sensing systems: radar, wind profiler, lidar, sodar, and passive radiometer systems. Integration of remote sensing measurements to retrieve properties of atmospheric phenomena. Hands on usage and field measurements. Prerequisites: ATS 541.

ATS 672 - DUAL POLARIZATION RADAR MTRLGY
Semester Hours: 3

Theory, analysis and interpretation of dual polarization radar for meteorological applications. Course covers dual polarization radar system hardware; the basic theory underlying polarimetric radar data and methodology; analysis, interpretation and application of polarimetric radar variables; and dual meteorological and convective weather applications; specifically, precipitation measurement and hyrometeor identification. Example applications include rain rate estimation, drop size determination, hail identification, tornado detection, snow vs rain delineation, and cloud electrification studies. Prerequisites: ATS 571.

ATS 673 - LIGHTNING
Semester Hours: 3

An introduction to lightning. Topics include qualitative and quantitative description of lightning discharges; electrification of thunderstorms; temporal and spatial variation of lightning on multiple scales; various types of lightning; basic lightning models; current methods of measuring lightning. Prerequisites: ATS 509.

ATS 675 - ATMOSPHERIC DATA ASSIMILATION
Semester Hours: 3

Data assimilation methods and concepts including objective analysis and initialization as relevant to numerical weather prediction. Emphasis on variational methods, successive correction, optimal interpolation, adjoint and gradient concepts, singular vectors, Kalman filters and nudging. Prerequisites: ATS 541 and ATS 551.

ATS 681 - NUMERICAL ATMOS MODELING
Semester Hours: 3

Introduction to numerical methods applied to simulation of the atmosphere. Basic numerical solution techniques, along with filtering, radiative parameterizations, thermodynamics, turbulent parameterization, initialization and coordinate transformation. Prerequisites: ATS 551.

ATS 690 - SEL TOPICS IN ATMOS SCI
Semester Hours: 1-4

Selected topics of interest not included under other courses.

ATS 699 - MASTER'S THESIS
Semester Hours: 1-6

Required each semester a student is enolled and receiving direction on a master's thesis.

ATS 740 - CLOUD PROCESSES
Semester Hours: 3

Theory and observations of the bulk microphysics and kinematic structures of clouds. Topics include: interactions among dynamical, microphysical and thermodynamic processes within cloud systems, the dynamics of organized convective systems, and remote sensing of clouds and precipiation features. Prerequisites: ATS 541 and ATS 551.

ATS 761 - ATMOSPHERIC RADIATION II
Semester Hours: 3

Advanced topics in atmospheric radiative transfer. Specific topics include Maxwell equations, Mie theory, polarization and radiative transfer in a scattering atmosphere. Prerequisites: ATS 561.

ATS 762 - MICROPARTICLE OPT & RADIOMETRY
Semester Hours: 3

Propagation of electromagnetic radiation. Maxwells equations, Kramers-Kronig analysis, Mueller matrices, Stokes vectors, Rayleigh theory, scattering & absorption by single & multi sphere, near & internal fields, geometric optics, discrete dipole approximation, & T-matrices. Prerequisites: ATS 561.

ATS 770 - SATELLITE REMOTE SENSING
Semester Hours: 3

Using various satellite data sets and radiative transfer models, this course will train students to calculate and study cloud, aerosol, ocean and land surface properties to assess the radiative energy budget of the earth-atmosphere system. Prerequisites: ATS 670.

ATS 780 - ATMOSPHERIC SCIENCE SEMINAR
Semester Hour: 1

Speakers are invited to report on research relevant to the field of atmospheric science. Students are expected to attend at least twelve seminars and to write short descriptions of the presentations.

ATS 781 - STUDENT SEMINAR
Semester Hour: 1

Guest speakers report on research relevant to the fields of Atmospheric and Earth System Science. Students are expected to attend weekly seminars, submit a paper based on at least ten talks, and make a 15-minute conference type presentation on a research topic in atmospheric science selected in agreement with their advisor. Prerequisites: ATS/ESS 780.

ATS 782 - PROFESSIONAL DEVELOPMENT
Semester Hour: 1

Topics concerning professional ethics, writing scientific journal articles, proposals and resumes, preparing budgets, networking, time management, conference presentations, research administration, funding agencies, stress and burnout will be discussed. Selected topics of interest not included under other courses.

ATS 790 - SEL TOPICS IN ATMOS SCI
Semester Hours: 1-4

Selected topics of interest not included under other courses.

ATS 799 - DOCTORAL DISSERTATION
Semester Hours: 3-9

Required each semester student is enrolled and receiving direction on a doctoral dissertation.