ATMOSPHERIC SCIENCES (ATS)

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GRADUATE STUDY IN ATMOSPHERIC SCIENCES

Creighton University offers courses and experience leading to the Master of Science degree with a major specialization in Atmospheric Sciences or Environmental Sciences. The purposes of this program are to provide professional-level graduate education appropriate to preparation for advanced careers in meteorology, and the environment, with such agencies as the National Weather Service, the United States Air Force Weather Service, and various environmental and meteorological research and management organizations within the government and private industry. The program is available under a thesis (Plan A) or non-thesis (Plan B) approach, as outlined below.

Program Goals

At the completion of their graduate program, the student will:

1. Demonstrate an appreciation for and understanding of the principles of physical and dynamic meteorology.
2. Demonstrate the ability to apply these principles to the solution of an original problem related to the earth's atmosphere, the earth's oceans or the atmosphere of other planets.
3. Effectively communicate these research findings orally and in writing through an appropriate venue such as professional conference or peer reviewed journal.

ATMOSPHERIC SCIENCES

Faculty

Professor: J. Zehnder
Professor Emeritus: A. Douglas;
Associate Professor: J. Schrage.

Admission Requirements

Applicants holding a Bachelor of Science degree in meteorology, physics, or related natural and/or physical sciences, with undergraduate grade point averages of at least 3.0 are preferred. Graduate Record Examination (GRE) scores are required of all applicants; no advanced tests on the GRE are required. Inquiries and applications are invited from the Dean of the Graduate School, Creighton University, Omaha, Nebraska 68178.

Master of Science (M.S.) With a Major in Atmospheric Sciences

The Masters Degree program is structured as outlined in the following paragraphs. The overall basic requirements are presented in Table 1.

Table 1. Total Credit Hour Requirements: 33 Credits

Minimum Credit Hours from Courses 600-Level and above: 18 credits

Considering the diversity of student backgrounds presented by the prospective students, the Master's Degree program offers a generalized approach built upon a basic foundation (500-level course requirements), then branching to a structure associated with specialized areas of concentration (600-level course requirements). The students may take either of two approaches to completing the degree, Plan A, the traditional original research thesis or Plan B, the option to take a non-thesis approach. Under Plan B, the student may complete 33 credits of regularly scheduled classes, or may complete their studies with ATS 797, leading to a Departmental-level seminar and paper of potentially publishable quality and length.

Core Preparation Requirements:

The Master's Degree program offers two core tracks, with further specialization and concentration becoming available as the student's work progresses. This course sequence is designed to prepare the students for the more rigorous demands of the 600-level offerings required for degree completion. Students would be required to take at least 15 hours from either core track.

Atmospheric Core

Designed for students interested in enhancing current forecasting skills or diversifying into broader areas for continuing future studies, the contents of this core area are presented in Table 2.

Table 2. Atmospheric Core Course Content

ATS 542	Radar Meteorology	3 credits
ATS 545	Mesoscale Meteorology	3 credits
ATS 552	Boundary Layer Meteorology	3 credits
ATS 553	Tropical Meteorology	3 credits
ATS 555	Satellite Meteorology	3 credits
ATS 561	Synoptic Meteorology I	3 credits
ATS 562	Synoptic Meteorology II	3 credits
ATS 564	Statistical Applications	3 credits
ATS 571	Dynamic Meterology I	3 credits
ATS 572	Dynamic Meterology II	3 credits
ATS 573	Cloud Physics and Dynamics	3 credits

Note: Students entering the Master's Degree program who do not have a bachelor's in Meteorology/Atmospheric Sciences may take these classes for inclusion in their degree program.

Environmental Core

Designed for students interested in the identification, measurement, and assessment of environmentally oriented aspects of atmospheric sciences, the contents of this core area are presented in Table 3.

Table 3. Environmental Core Course Content

ATS 541	Ats. Diffusion, Air Pollution & Environmental Impact	3 credits
ATS 542	Radar Meteorology	3 credits
ATS 544	Hydrology	3 credits
ATS 552	Boundary Layer Meteorology	3 credits
ATS 553	Tropical Meteorology	3 credits
ATS 555	Satellite Meteorology	3 credits
ATS 562	Synoptic Meteorology II	3 credits
ATS 564	Statistical Applications	3 credits
ATS 574	Stratospheric Dynamics	3 credits
BIO 523	Environmental Toxicology	3 credits
BIO 540	Flora of the Great Plains	4 credits
BIO 545	Applied Limnology and Water Quality	4 credits
BIO 549	Environmental Physiology	3 credits
BIO 561	Entomology	4 credits
BIO 571	Animal Behavior	3 credits
BIO 572	Animal Behavior Laboratory	2 credits
BIO 581	Evolution	4 credits
CHM 506	Environmental Chemistry and Natural Resources	3 credits

Individual Advanced Core Specialization:

The student is presented with the opportunity to focus the remainder of their program in one or more areas of study depending upon their interest and need. At least 18 hours are to be taken from these additional Department offerings. Normally, no more than three hours may be credited towards a degree from among 646, 670, and/or 793, and up to six hours from 795/(Independent Study), 797 (Independent Research)/799 (Master's Thesis). Table 4 lists advanced core offerings of the recent past, illustrating the diversity available to the student.

Table 4. Typical Advanced Core Offerings

ATS 615	Radar and Severe Storms	3 credits
ATS 624	Advanced Dynamics I	3 credits
ATS 625	Advanced Dynamic Meteorology II	3 credits
ATS 631	Numerical Weather Prediction	3 credits
ATS 632	Advanced Numerical Weather Analysis and Prediction	3 credits
ATS 652	Atmospheric Boundary Layers and Turbulence	3 credits
ATS 663	Weather Systems Analysis	3 credits
ATS 675	Advanced Stratospheric Dynamics	3 credits
ATS 793	Directed Independent Readings	1-3 credits
ATS 795/797	Non-thesis Track (Plan B)	1-3 credits
ATS 797/799	Thesis Track (Plan A)	1-3 credits

ATS 510 Introduction to Physical Meterorology (3) I
The purpose of this course is to introduce the student to the physics of atmospheric processes. Topics include the structure and composition of the atmosphere; thermodynamics of gases; vertical and horizontal transport of heat by radiative and turbulent processes; the structure and evolution of the atmospheric boundary layer; and cloud microphysical processes. This course is designed to meet the National Weather Service requirement for 3 semester hours of Physical Meteorology.

ATS 516 Computer Methods in Atmospheric Sciences (3) II, AY (2009)
Intermediate computer techniques currently used in atmospheric science. Emphasis on graphic methods, fundamental techniques of numerical prediction, parallel processing, and artificial intelligence. Applications of these methods to short-term forecasting. **P: ATS 315.**

ATS 531 Operational Prediction Models (3) II, AY (2008)
Examination of the use of forecast models from the National Meteorological Center (LFM, Spectral, NGM). Additional models from other sources will also be examined (UKMET, ECMWF, USAF, and USN). Study of model domain, resolution and formation with respect to physical processes. Model performance is described and scrutinized (with respect to systematic errors and to particular synoptic situations). Comparative diagnostics of forecast and observed fields employed to examine model behavior. **P: ATS 562 or IC.**

ATS 532 Objective Meteorological Analysis (3) OD
Application of techniques and principles for temporal and spatial computer analysis of atmospheric data based on dynamical concepts, with a focus on the structure, movement, and development of weather systems. Topics include data time series, statistical inference techniques, Fourier analysis, and map projections and grid systems used in meteorology. **P: ATS 571 and computer programming.**

ATS 533 Physical Climatology and Climate Change (3) II (Same as EVS 533)
This course stressed the theories and models of natural climate change and of that induced by human beings. The ethical issues of inadvertent and planned change of climate by humans will be raised. Major topics include effects of CO2 warming (greenhouse effect), ozone depletion; human-induced desertification; acid rain; urban microclimates. Methods of monitoring these systems will be stressed relative to an increased world-wide need to limit or prevent human-induced climate changes.

ATS 541 Atmospheric Diffusion, Air Pollution, and Environmental Impact Analysis (3) OD
Survey of the theoretical and practical aspects of diffusion, dispersion, and turbulent transport of pollutants in an atmospheric boundary layer. Includes observational and instrumentation techniques; plume models; regional pollution transport; and diffusion from point, line and area sources. Chemical and physical transformations of the pollutants, precipitation scavenging, and dry deposition are studied. Reviews Federal environmental laws, air quality standards, environmental impact assessments, ethics, and guidelines for writing environmental impact statements. **P: ATS 113 or equiv.**

ATS 542 Radar Meteorology (3) I
The theoretical and practical aspects of weather radar. Stress placed on the capabilities and limitations of severe storm investigation. **P: MTH 245; PHY 212; or IC.**

ATS 544 Hydrology (3) OD
Study of the waters of the earth, especially with relation to the effects of precipitation and evaporation upon the occurrence and character of water in streams, lakes, and on or below the land surface. In terms of hydrologic cycle, the scope of this course may be defined as that portion of the cycle from precipitation to reevaporation or return of the water to the seas. **P: ATS 113 or ATS 231.**

ATS 545 Mesoscale Analysis (3) II
Examination of the theory of convection as related to models of squall lines and thunderstorms and the application of this theory to the forecasting and analysis of sub-synoptic scale systems. **P: ATS 562 and ATS 571.**

ATS 548 Introduction to Solar-Terrestrial Environment (3) OD (Same as EVS 548)
Course designed to acquaint the student with the basic phenomenology associated with solar processes and activity, and the impact of these processes upon the earth and its atmosphere. Designed to familiarize the student with the concepts of upper atmospheric energetic processes and their influences upon everyday activities.

ATS 552 **Boundary Layer Meteorology** (3) OD
Structure of the boundary layer, surface energy budget, vertical profiles of temperature, humidity and wind, turbulence, Monin-Obukhov theory. Determination of surface heat and moisture fluxes. Some discussion of applications to diffusion and dispersion of substances in the atmosphere. **P: ATS 572 or equiv.**

ATS 553 **Tropical Meteorology** (3) I, AY (2008)
Characteristics of the tropical atmosphere including convection, boundary layer processes, local and diurnal weather phenomena, mesoscale tropical systems, tropical storm structure, and energetics. This course relies heavily on satellite interpretation of tropical cloud systems. **P: ATS 113.**

ATS 555 **Meteorological Remote Sensing** (3) II
Examines the relationship between clouds and other atmospheric features as revealed by weather satellites and applies this information to analysis and forecasting of weather systems. Seasonal satellite film loops are used to identify the evolution of circulation systems. Includes a brief introduction to aerial photography and landscape photography. **P: ATS 113 or IC.**

ATS 556 **Introduction to Physical Oceanography** (3) I, AY (2008)
Geomorphology of the ocean bottom; properties of sea water, salinity and temperature distributions; major ocean currents and circulations; equations of motion, horizontal wind-driven currents; thermohaline circulations; wind waves and swell.

ATS 561 **Synoptic Meteorology I** (3) I
Examination of weather code, plotting and map analysis. Includes a review of cyclone and frontal theory using case studies to develop diagnostic and forecasting techniques. Practical applications of air mass and frontal analysis are related to weather forecasting. **P: ATS 113 or IC.**

ATS 562 **Synoptic Meteorology II** (3) II
Detailed examination and use of fax charts, GEMPAK displays, and other tools employed in analysis and forecasting. Review of methods in short-term, medium and long-range forecasting. **P: ATS 561 or IC.**

ATS 564 **Statistical Applications in the Atmospheric Sciences** (3) OD
Study of the statistical distributions of scalars and vectors, sampling theory, regression, correlation, and time series. Applications to statistical forecasting and forecast verification. **P: MTH 245.**

ATS 565 **Atmospheric Circulation Systems** (3) OD
Examination of the general circulation of the atmosphere. Emphasis on seasonal variation in both hemispheres. Exploration of formation of anomalous circulation types with respect to anomalous boundary layer conditions. Detailed discussion of tropical-mid latitude interactions. **P: ATS 562 or IC.**

ATS 566 **Climate Theory** (3) OD
Theories of global climate and variability. Examination of climate models, including internal and external parameters and feedback mechanisms. **P: ATS 113, 561.**

ATS 570 **Quantitative Methods in the Atmospheric Sciences** (3) II
Overview of mathematical and statistical methods employed by atmospheric scientists, including a review of key calculus concepts. Topics include coordinate systems, vector operators, finite difference approximations, vector calculus, regression, filtering, hypothesis testing and key theorems. **P: MTH 246.**

ATS 571 **Dynamic Meteorology I** (3) I
Equations of motion and thermodynamics will be vigorously derived and applied to the atmosphere. Topics include thermodynamics of dry and moist air, hydrostatic and hypsometric approximations, geostrophic and gradient wind balance, mass continuity, and vorticity. **P: PHY 213; MTH 246.**

ATS 572 **Dynamic Meteorology II** (3) II
Concepts presented in ATS 571 will be further developed and applied to the following topics: barotropic and baroclinic instability, atmospheric oscillations, quasi-geostrophic theory, and simple numerical modeling. **P: ATS 571.**

ATS 573 **Cloud Physics and Dynamics** (3) OD
Thermodynamic processes which control the development and growth of clouds. Relationship between atmospheric properties and cloud structure. Distribution of condensation nuclei, water droplet spectra. Initiation and growth of cloud hydrometers. Structure of severe storms, radiative effects of clouds. **P: ATS 571.**

ATS 574 **Stratospheric Dynamics** (3) OD
Study of the principles governing atmospheric motions in the stratosphere. Includes a brief review of chemical processes, radiative effects, and the resulting thermal structures that govern the mean stratospheric circulation; forcing mechanisms and conditions for wave generation in the stratosphere; discussions of sudden warmings, quasi-biennial and semiannual oscillations, and tropical wave phenomena in the stratosphere. **P: ATS 571.**

ATS 575 **Environmental Measurements Practicum** (3) OD (Same as EVS 575)
This course is designed to provide the students with instruction on the principles and practices associated with environmental measurements of the atmosphere, soil and hydrologic courses. Heavy emphasis will be placed on the theory of sampling ambient and pollutant sources, instruments and measurement techniques, and the consequences of the pollutant. The course will include several exercises as well as field trips to local sites of interest to demonstrate the practical and operational aspects of environmental measurement and monitoring programs. **P: ATS/EVS 113, MTH 245 and PHY 212 or IC.**

ATS 615 **Radar and Severe Storms** (3) II, AY (2008)
Examination of the fundamentals of weather radars (coherent and noncoherent) and their application to detecting severe storms. Topics include properties of electromagnetic waves; radar detection of spherical particles; use of radar for quantitative measurement of precipitation; radar beam characteristics; the use of radar in mesometeorology; the study of severe storms; Doppler weather radar; theory and recent developments applied to severe storm detection and warning. **P: ATS 545 or IC.**

ATS 624 **Advanced Dynamics I** (3) II, AY (2008)
Detailed examination of the fundamental physical processes occurring in the atmosphere through the use of thermodynamic and hydrodynamic equations. Subjects treated include geophysical and fluid mechanics, geostrophic adjustment, nongeostrophic baroclinic instability, energetics, and equatorial general circulation. **P: ATS 572 or equiv.**

ATS 625 **Advanced Dynamic Meteorology II** (3) OD
Continuation of ATS 624. **P: ATS 624.**

ATS 626 **General Circulation** (3) OD
The course will apply the fundamental principles of dynamic meteorology and energetics of the atmosphere to explain the major features of the observed general circulation. Explores tropical mid-latitude interactions and anomalous circulation types. **P: ATS 571 or equiv.**

ATS 631 **Numerical Weather Prediction** (3) I, AY (2009)
Descriptive and mathematical foundations for numerical weather prediction. History of numerical weather prediction, analysis and initialization methods, the governing equations and analytic solutions to simplified forms of these equations, finite differentiating techniques and problems in numerical weather prediction. **P: ATS 572**.

ATS 632 **Advanced Numerical Weather Analysis and Prediction** (3) OD
Theory of analysis techniques such as spectral analysis and optimal interpolation; conventional gridpoint, spectral, and fine-element models; map projections; the principle of statistical correction to model forecasts and stochastic-dynamic prediction. Practical experience in numerical forecasting is obtained through a project in which a numerical model is developed and numerical methods are applied. **P: ATS 631 or equivalent.**

ATS 642 **Physical Meteorology** (3) I, AY (2008)
This course examines the physical properties of the atmosphere. The course begins with a general description of the physical properties of the global Earth atmosphere, both horizontally and vertically. Atmosphere thermodynamics are discussed in detail including: the dry and moist atmosphere, diabatic and adiabatic processes and Newton's 2nd law, hydrodynamic stability and atmospheric instability, solar and terrestrial radiation, cloud microphysical and optical properties are all thoroughly examined. This course is designed to meet the National Weather Service requirement for 3 semester hours of Physical Meteorology.

ATS 643 **Radiation Through the Atmosphere** (3) OD
Introduction to the physical processes of radiation and the theory of radiative transfer through the atmosphere, including definitions, basic radiation laws, absorption, emission, and scattering processes; the radiative transfer equation; and simple solutions. Applied to visible, infrared and microwave radiation, with special emphasis on providing the background necessary for understanding theory and techniques of remote sensing. **P: Two semesters of calculus.**

ATS 644 **Remote Sensing Theory** (3) OD
Provides theoretical background for further work in remote sensing of the earth and atmosphere. Topics include electromagnetic theory; Maxwell's equations; the absorptive and emissive properties of the earth-atmosphere system; the scattering properties of the atmosphere, including Mie scattering, calculations of forward radiative transfer and inversion of radiation measurements. **P: Two semesters of calculus.**

ATS 646 **Current Topics in Remote Sensing** (3) OD
Advanced course in remote sensing, including the latest work in atmospheric temperature and constituent analysis and in terrestrial and oceanographic sensing.

ATS 647 **Solar-Terrestrial Relationships** (3) OD
Basic features of solar activity, the solar wind, and effects of the sun on the earth beginning with an overview of stellar evaluation. Class lectures will trace the processes as solar energy is transported into space and the earth's atmosphere. Includes introductory solar physics, magnetospheric dynamics, and thermospheric and ionospheric processes.

ATS 652 **Atmospheric Boundary Layers and Turbulence** (3) OD
The conservation equations of heat, moisture, mass, and momentum for the lowest two kilometers of the earth's atmosphere are expanded into mean and turbulent components and scaled to the boundary layer. Closure approximations and the statistical nature of turbulence are discussed. Observations of turbulent boundary layers are reviewed and compared with theoretical predictions. Similarity models are applied to the surface layer and parametric models are applied to the mixed layer.

ATS 660 **Advanced Terrestrial Remote Sensing** (4) OD
This course covers the technique and applications of observing the Earth from air- and space-bourne instruments. We will cover basic issues of geometry and scale associated with making these measurements, electromagnetic properties of Earth surface materials, the range of instruments used to observe the Earth, and applications of satellite remote sensing to geological, environmental, and atmospheric questions. The course will involve substantial research project utilizing remote sensing data and software. Graduate students will also be expected to do an oral presentation to be arranged with the instructor.

ATS 663 **Weather Systems Analysis** (3) OD
Application of fundamental analysis and diagnostic strategies to weather systems. Topics include meteorological data sources and errors, scalar analysis, cross-section and isentropic analysis, surface and upper air analysis, kinematic analysis, deformation and frontogenesis, quasi-geostrophic and isentropic potential vorticity diagnostics. Case studies of major weather systems are employed to demonstrate various analysis strategies and to synthesize a coherent picture of weather system structure and the processes that create that structure. Emphasis on computer assisted analysis and diagnosis. **P: ATS 571 or IC.**

ATS 666 **Climate Theory** (3) OD
Theories of global climate and climate variability. Climate models (including internal and external parameters) and feedback mechanisms will be developed and examined. **P: ATS 561 and 562 or equiv.**

ATS 670 **Current Topics in Atmospheric Sciences** (3) OD
Examination of topics of current interest in the atmospheric sciences. Course may include but not be limited to such areas as aeronomy, weather modification, interactive computer graphics, synoptic-scale forecasting and analysis, meso- and micro-scale meteorology, meteorological instrumentation, military applications of the atmospheric sciences; meteorology of other planets, and aerology and atmospheric physics.

ATS 674 **Aeronomy** (3) OD
Basic features of the technical disciplines comprising the field of aeronomic studies. Starting with an overview of solar processes and phenomena, class lectures will trace the processes as solar energy is transported into space and into the earth's atmosphere. Includes introductory solar physics, magnetospheric effects, thermospheric and ionospheric processes, and special optical phenomena, e.g., aurora and airglow. Students will be exposed to a wide spectrum of highly specialized technical areas with the intent of directing them into more advanced, specialized, in-depth studies. **P: ATS 571.**

ATS 675 **Advanced Stratospheric Dynamics** (3) OD
Course designed to acquaint the student with the diverse dynamic processes responsible for forming and maintaining the earth's stratosphere. Topics discussed include the radiative and chemical processes responsible for creating the region, periodic changes observed and their significance, and techniques used to measure and observe phenomena in this region. Depending upon the experience levels of the students enrolled, individual specialized exercises may be added to the usual lectures to increase the student's involvement and understanding.

ATS 793 **Directed Independent Readings** (1-3) I, II, S
One or more students will follow a series of readings, as specified by a faculty member, on a single topic or a range of associate topics. This allows students to explore topics not offered in the current courses or to pursue more advanced study in an area covered in a previous course. A maximum of three semester hours may be taken. **P: IC.**

ATS 795 **Directed Independent Study** (1-3) I, II, S
Advanced study in a specific area of interest to the faculty and students. During the course of their research, students are expected to set up scheduled meetings with their advisors. At the end of his/her study, the student will give an oral presentation which highlights the final study report. **P: IC.**

ATS 797 **Directed Independent Research** (1-3) I, II S
Each student, supervised by a specific faculty member, pursues in-depth reading and research on a single topic. At the end of the project, the student will make a presentation with the research. A paper of publishable quality and length is to be prepared by the student, to the satisfaction of the research committee. In this manner, the student is introduced to scientific research methods and encouraged in the development of both verbal and written communication skills. **P: IC.**

ATS 799 **Master's Thesis** (1-3) I, II, S
Research in connection with the preparation of the Master's thesis. Students must register for this course in any term when engaged in formal preparation of the Master's thesis; however, six credit hours are the maximum applicable toward the degree. **P: IC.**