The Atmospheric Sciences (ATM) program is designed to prepare students with the tools, training, and education necessary to tackle critical research problems in the atmospheric sciences today. Our faculty are experts in a wide range of research areas, including tropical meteorology, climate dynamics, cloud and aerosol processes, and atmospheric chemistry. Their expertise and guidance and our world-class facilities prepare our students for successful careers in the atmospheric sciences and related fields.

### Degree Programs

- **Master of Professional Science (M.P.S.)** (p. 1)
  - Requires 30 credit hours, including 24 course credit hours and 6 internship credit hours.
- **Master of Science (M.S.)** (p. 1)
  - Requires 30 credit hours, including 24 course credit hours and 6 research credit hours.
- **Doctor of Philosophy (Ph.D.)** (p. 2)
  - Requires 60 credit hours, including a minimum of 26 course credit hours and a minimum of 12 research credit hours.

### Research Areas

#### Atmospheric Chemistry

The atmospheric chemistry group in ATM is interested in understanding the atmospheric emissions, transport, and fate of gases and particles that influence air quality and climate. These interests are explored through laboratory studies and fieldwork. Using state-of-the-art instrumentation and techniques, ATM scientists take measurements in tropical and high-latitude oceans, in forests and urban centers, and at the critical air-sea and troposphere-stratosphere interfaces. These measurements are used in models to predict the impact of atmospheric chemistry on human health and climate.

#### Climate Dynamics & Prediction

Climate research in ATM includes numerical climate modeling at both regional and global scales, and analysis of satellite data, global data products, and observations. There is a large focus on the diagnosis and modeling of climate variability on interannual, decadal, and millennial timescales, the prediction and modeling of El Niño, and the observation and modeling of anthropogenic climate change.

#### Cloud & Aerosol Processes

Scientists in ATM study aerosols, clouds, their interactions with each other, with radiation, and with the larger-scale environment. We strive for a better understanding of the cloudy boundary layer structure, its processes, and the effects of atmospheric transport of aerosols such as dust, smoke, and air pollutants, upon both air quality and climate. A focus on marine aerosols and south Florida’s Cloud-Aerosol-Rain-Observatory (CAROb) takes advantage of Miami’s unique location on the edge of the Atlantic basin.

#### Tropical Meteorology & Hurricanes

One broad area of research in ATM is aimed at improving our understanding and prediction of tropical weather and hurricanes. Through a combination of field observations, modeling, and theory, faculty and students study the dynamics of hurricanes: their formation, rapid intensification, and how their behavior might change in a warming climate. Other research foci include the advancement of computer model forecasts of tropical cyclones, data assimilation schemes, and observation strategies. Other weather phenomena in the tropics are also investigated in ATM and through the Rosenstiel School, such as monsoons, the intertropical convergence zone, and the Madden-Julian Oscillation.

#### Other Research Areas

Researchers in ATM also perform research in a number of other areas including:

- Geophysical Fluid Dynamics
- Tornado Dynamics
- Atmospheric Boundary Layer
- Atmospheric Convection
- Model Parameterizations
Master of Professional Science (M.P.S.) Programs
There are three ATM tracks for the M.P.S. degree:

- M.P.S. in Broadcast Meteorology (BME) (http://bulletin.miami.edu/graduate-academic-programs/marine-atmospheric-science/atmospheric-sciences/broadcast-meteorology-mps)
- M.P.S. in Weather Forecasting (WFC) (http://bulletin.miami.edu/graduate-academic-programs/marine-atmospheric-science/atmospheric-sciences/weather-forecasting-mps)

Master of Science (M.S.) Programs

- M.S. in Atmospheric Sciences (ATM) (http://bulletin.miami.edu/graduate-academic-programs/marine-atmospheric-science/atmospheric-sciences/atmospheric-sciences-ms-phd)

Doctor of Philosophy (Ph.D.) Programs

- Ph.D. in Atmospheric Sciences (ATM) (http://bulletin.miami.edu/graduate-academic-programs/marine-atmospheric-science/atmospheric-sciences/atmospheric-sciences-phd)

ATM 611. Geophysical Fluid Dynamics I. 3 Credit Hours.
The basic equations of state, continuity, and motion. Topics include wave motions, group velocity, theory of stratified fluids and internal waves turbulences.

Components: LEC.
Grading: GRD.
Typically Offered: Fall.

ATM 614. Introduction to Weather and Climate. 3 Credit Hours.
This course will cover the structure, physics, dynamics and thermodynamics of the atmosphere; including weather analysis, weather forecasting, climate and climate change. Contemporary topics covered in this class will include global warming, the ozone hole, hurricanes, thunderstorms and other severe weather phenomena.

Components: LEC.
Grading: GRD.
Typically Offered: Fall.

ATM 615. Numerical Weather Prediction. 3 Credit Hours.
Review of fundamental equations and principal wave solutions. Course topics include finite differences, the filtering problem, the equivalent-barotropic model, multi-level primitive equation models, model initialization and verification, and models currently used by the weather service.

Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

ATM 624. Applied Data Analysis. 3 Credit Hours.
The course is intended to jump-start students in strategies for fruitful computer interaction practices for careers in MPO areas of science. Academic topics include key concepts in probability & statistics, issues of graphical evidence and inference, linear models and regression, spectral analysis, and matrix decomposition. Practical topics include hands-on exercises in data analysis and the sharing of code+results and interpretation. Students do projects on data from their research or interests.

Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

ATM 633. Atmospheric Boundary Layer. 3 Credit Hours.
The boundary layer is the lowest 1-2 km of the atmosphere, where we live. It is necessary to understand boundary layer processes to pursue research in clouds and radiation, weather and climate, air/sea/land interaction, and chemistry of the lower atmosphere. In this course, students will learn the basic physical concepts, from observational, theoretical and modeling perspectives.

Components: LEC.
Grading: GRD.
Typically Offered: Spring.
ATM 634. Atmospheric Chemistry. 3 Credit Hours.
This course is an introduction to Atmospheric Chemistry for students in Atmospheric Science and Ocean Science. The course will discuss major topic areas of atmospheric chemistry with an emphasis on providing links between atmospheric chemistry, meteorology, ocean science, and climate. Background in General Chemistry and Mathematics (through Calculus) is recommended.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

ATM 636. Hurricanes. 3 Credit Hours.
This course is intended to provide a broad overview of tropical cyclones, starting from the basic structure, dynamics and thermodynamics, then expanding through to observations, modeling, forecasting and impacts.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 637. Natural Hazards: Atmosphere and Ocean. 3 Credit Hours.
This course is designed to provide students with an understanding of natural hazards in both the atmosphere and ocean. In the atmosphere, we will explore both weather events such as storms and hurricanes and tornadoes as well as longer term phenomena such as monsoons and excess rainfall in the tropics. Oceanographically, the course will address hazards such as storm surge and flooding, rogue waves, rip currents, and tsunamis that occur on short time scales as well as the longer term effects such as sea level rise and the impacts of El Niño and La Niña oceanographic conditions on weather conditions. Thus, the course focus is on hazards and their impacts around the globe.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 651. Introduction to Atmospheric Science. 3 Credit Hours.
Thermodynamics of dry and moist processes; elementary dynamical meteorology; description of weather systems and phenomena on all scales; structure and mechanics of the general circulation.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 653. Climate Change. 3 Credit Hours.
Overview of the physical processes which regulate the earth's climate and response to forcing.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

ATM 654. Climate Variability. 3 Credit Hours.
This class will cover the physical mechanisms that govern the earth's climate and climate variability. It is intended for beginning graduate students in marine and atmospheric science, and upper-level undergraduate physical science students.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 660. Tropospheric Chemistry I. 3 Credit Hours.
Process-Oriented lower atmospheric chemistry. Topics include photochemical oxidant formation, nighttime chemistry, air-sea exchange, cloud droplet and aerosol reactions, physical properties of aerosols, and transport properties of the troposphere.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 661. Tropical Atmosphere and Ocean. 3 Credit Hours.
Observed structure of large-scale tropical circulations, including the Trades, the intertropical Convergence Zone, the Walker circulation, and equatorial wave disturbances. An overview of tropical climate, including El Niño/Southern Oscillation, and tropical monsoons is included as well as the formation, structure, and dynamics of tropical cyclone interactions between tropical convection and large-scale circulations, equatorial waves, and flow instabilities.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.
ATM 662. Advanced Weather Forecasting. 3 Credit Hours.
Students will learn the skills needed in researching and preparing a professional weather forecast. There is a plethora of forecast resources available online. Students will learn about using these forecast resources and share resources of their own. Specifically, we will cover topics such as the basics of atmospheric meteorology, large and small scale weather forecasting, operational weather forecasting, tropical weather, severe weather, nor’easters, lake effect snow, oscillations and various other weather phenomena. During the course of the semester a couple of Guest speakers in various parts of the field will visit to discuss relevant topics.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

ATM 663. Mesoscale Meteorology and Severe Storms. 3 Credit Hours.
Course topics include the structure and dynamics of clouds, thunderstorms, and mesoscale convective systems, radar and satellite observations of clouds and precipitation, severe storm forecasting, mesoscale disturbances, frontal and orographic clouds, and precipitation.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

ATM 681. Special Topics. 1-4 Credit Hours.
Lectures, research projects or directed readings in special topics related to Atmospheric Sciences.
Components: LEC.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

ATM 682. Special Topics. 3 Credit Hours.
Lectures, research projects or directed readings in special topics related to Atmospheric Sciences.
Components: LEC.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

ATM 683. Special Topics. 1-4 Credit Hours.
Lectures, special projects or directed readings in special topics related to Atmospheric Sciences.
Components: LEC.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

ATM 684. Special Topics. 1-4 Credit Hours.
Lectures, special projects or directed readings in special topics related to Atmospheric Sciences.
Components: LEC.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

ATM 685. Special Topics. 1-4 Credit Hours.
Lectures, research projects or directed readings in special topics related to Atmospheric Sciences.
Components: LEC.
Grading: GRD.
Typically Offered: Fall, Spring, & Summer.

ATM 701. Seminar in Atmospheric Sciences. 1 Credit Hour.
Oral presentation of research and special topics by students, faculty, and visiting scientists.
Components: SEM.
Grading: SUS.
Typically Offered: Fall & Spring.

ATM 711. Geophysical Fluid Dynamics II. 3 Credit Hours.
The focus of this course is on the effects of stratification, on time variable phenomena, and on the interaction between large-scale circulation and mesoscale eddies. Course topics include quasi-geostrophic scale analysis, Rossby waves, barotropic and baroclinic instability, wave-mean flow interaction and non-geostrophic waves.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 713. Predictability. 3 Credit Hours.
Introduction to concepts of predictability and error growth, beginning from the seminal papers of Ed Lorenz, and expanding into state estimation, data assimilation, forecast sensitivity and ensemble prediction.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.
ATM 731. Air-Sea Interaction. 3 Credit Hours.
Oceanic and atmospheric mixed layers including fluxes of heat, momentum, moisture and salt between the ocean and atmosphere; vertical
distribution of energy sources and sinks at the interface including the importance of surface currents; forced upper ocean dynamics, the role of
surface waves on the air-sea exchange processes and ocean mixed layer processes.
Components: LEC.
Grading: GRD.
Typically Offered: Fall & Spring.

ATM 732. Climate Dynamics. 3 Credit Hours.
Basic understanding of the Earth's Climate System and its variability on time scales ranging from weeks to millennia. Topics include internal
atmospheric variability, coupled ocean-atmosphere interactions, and the theory, observations and modeling of climate change.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

ATM 734. Cloud Physics and Radiative Transfer. 3 Credit Hours.
This class provides a modern update to what has traditionally been labeled as "Physical Meteorology": the fundamental physical processes that can
occur in one day or less, and within one 1km or less. Such small-scale processes include aerosol, cloud and precipitation physics, and the radiative
transfer through the atmosphere. We add to this a consideration of the interactions of aerosols and clouds with the larger meteorological field, as
only through understanding the covariations between the aerosol and cloud physics and the larger-scale dynamical/thermodynamical fields can each
influence be identified. Current issues pertinent to climate and to weather will be explored, and modeling approaches treated. The radiative transfer
unit will develop a deeper appreciation of the concepts and mathematical tools, with exposure to radiative transfer codes. The course is split into 2
halves: the first half covers cloud physics, the 2nd half covers atmospheric radiation. Spring break provides a neat division of the two halves. The
course assumes knowledge at the Wallace and Hobbs level. The course work will include computer programming, and some computer literacy is
assumed.
Prerequisite: MPO 551.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 750. Reaction Kinetics and Molecular Dynamics. 3 Credit Hours.
Theories and experimental techniques for studying kinetics in the gas-phase, association, unimolecular and bimolecular reactions, chain reactions,
flames, statistical theories, potential energy surfaces, collision dynamics, kinetics in solution and the solid-state, experimental methods, diffusion-
controlled processes, transition state theory, thermal decomposition, and nucleation are discussed.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 752. Vortex Dynamics. 3 Credit Hours.
This course will cover fundamental to advanced topics in vortex dynamics. A review of fluid dynamics and vorticity in two dimensions will be followed
by studies of vortex dynamics in three-dimensional, incompressible flow and in three-dimensional, stratified flow.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

ATM 761. Atmospheric Chemistry II. 3 Credit Hours.
Advanced atmospheric chemistry.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

ATM 762. Computer Models in Fluid Dynamics. 3 Credit Hours.
Course topics include numerical techniques of dealing with dynamic problems in meteorology and oceanography. Dynamic prediction models, initial
data conditioning, computational stability, and error estimates are also included.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 764. Atmospheric and Oceanic Turbulence. 3 Credit Hours.
Structure and dynamics of planetary boundary layers, turbulent transport processes, Fickian and statistical theories of turbulence, influence of
stratification, and rotation on turbulent motion are discussed.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.
ATM 765. General Circulation of the Atmosphere. 3 Credit Hours.
Course topics include structure and behavior of planetary scale motions, energy, momentum, and moisture budgets of the general circulation, and models of the general circulation and climatic change.

Components: LEC.
Grading: GRD.
Typically Offered: Spring.

ATM 767. Spectral and Finite Element Methods in Computational Fluid Dynamics. 3 Credit Hours.
The simulation of fluid flows in geometrically complex domains (like ocean basins) and/or with high fidelity requires the adoption of new discretization techniques that can simultaneously handle the complicated geometry and permit high accuracy solution. The finite element method has traditionally been used to tackle the geometric complexity while spectral methods have been developed to handle high accuracy in simple geometries. Here we present an approach to handle both complexity within a single framework, namely the spectral element method. The course starts by describing the weak formulation common to all finite element methods which, by design, are geometrically flexible. The second part of the course describe how high order polynomial can be implemented within the finite element framework to achieve high accuracy rates.

Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

ATM 768. ENSO Dynamics, Prediction, and Predictability. 3 Credit Hours.
This course will provide students with a comprehensive observational and mechanistic understanding of the El Nino and the Southern Oscillation (ENSO) phenomena and how ENSO impacts the natural variability of the global climate system. Topics will include: Observations and theories of the seasonal and interannual changes in the ocean circulation and temperature, and interactions with the atmosphere; equations of motion and theories of tropical ocean and atmosphere circulation; tropical wave dynamics; large scale air-sea coupling; mechanisms for ENSO: delayed oscillator theory, recharge oscillator theory, slow SST modes; ENSO prediction and predictability; ENSO-monsoon-Indian Ocean interactions; Global climate response to ENSO; decadal ENSO variability; ENSO in a changing climate. This course has a phenomenological focus, which complements current MPO course offerings. In particular, students who have taken dynamic and physical meteorology, ocean general circulation or geophysical fluid dynamics will be exposed to how general theory (e.g., wave dynamics) relates to particular phenomena and current research foci. In addition, student will have the opportunity to design and implement numerical hypothesis testing experiments.

Components: LEC.
Grading: GRD.
Typically Offered: Fall.

ATM 774. Advanced Studies. 1-4 Credit Hours.
Supervised study of special interest to graduate students.

Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

ATM 805. MPS Internship. 1-6 Credit Hours.
The MPS internship is an approved, supervised internship project with an organization engaged in activities associated with the student's degree track. The internship results in a collaborative project, written report, and oral presentation on a topic approved by the student's advisory committee. Up to 6 credits are necessary for graduation.

Components: PRA.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.

ATM 810. Master Thesis. 1-6 Credit Hours.
The student working on his/her master's thesis enrolls for credit, in most departments not to exceed six, as determined by his/her advisor. Credit is not awarded until the thesis has been accepted.

Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.

ATM 830. Doctoral Dissertation. 1-12 Credit Hours.
Required of all candidates for the Ph.D. The student will enroll for credit as determined by his/her advisor but not for less than a total of 12. Not more than 12 hours of ATM 830 may be taken in a regular semester, nor more than six in a summer session. Where a student has passed his/her (a) qualifying examinations, and (b) is engaged in an assistantship, he/she may still take the maximum allowable credit stated above.

Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.