METEOROLOGY AND PHYSICAL OCEANOGRAPHY

https://www.graduate.rsmas.miami.edu/phd-and-ms-programs/meteorology-and-physical-oceanography/index.html

Dept. Code: MPO

The Meteorology and Physical Oceanography (MPO) graduate program was founded on the premise that oceanic and atmospheric dynamics are governed by a set of similar physical principles, and that much insight can be gained by studying their dynamics from a common perspective.

The MPO program requires students to develop expertise in both systems, and prepares students to conduct leading-edge research using a complementary set of theoretical, observational, and modeling approaches.

The MPO curriculum forms a strong foundation for research on a broad spectrum of topics that include air-sea interaction, the global thermohaline circulation, tropical cyclones, El Niño, the Madden-Julian Oscillations, and the evolution of the Earth's climate.

Degree Programs

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

Research Areas

The MPO program has a strong foundation in several areas in atmospheric and ocean sciences, including those presented below. Research is conducted using a variety of techniques from direct observation to theoretical and numerical modeling. Students come from a diverse range of educational backgrounds, including marine science, meteorology, physics, mathematics, and engineering.

Climate Variability and Change

Research covers a wide range of topics, both global and regional. We study climate variations on time scales from sub-seasonal to interannual to decadal, as well as ancient (paleo) climates and future climate changes. Efforts include analysis of satellite data, field observations and global data products, and a large focus on numerical climate modeling.

Large-Scale Ocean Circulation

Research covers a variety of topics, highlighting the ocean's role in climate, including dynamics and variability of boundary currents, meridional overturning and tropical circulations, as well interaction between large-scale, mesoscale and submesoscale circulations. Particular strengths include experimental oceanography, numerical modeling with a variety of comprehensive and conceptual models, data analysis and assimilation, and theoretical studies.

Tropical Dynamics

The tropics have global impacts, from weather effects and hurricanes to El Niño and other climate variations. Research involves the myriad interactions of water vapor and clouds with air and wind and the underlying tropical oceans and landscapes.

Hurricanes

RSMAS/MPO is ideally situated for the study of hurricanes through its location in Miami and its proximity to the NOAA Hurricane Research Division and National Hurricane Center. The research includes high-resolution coupled atmosphere-wave-ocean modeling, hurricane dynamics, and novel adaptive observing and data assimilation methods.

Regional and Coastal Oceanography

Studies focus on key processes in coastal and shelf areas, with special interest in regional seas around South Florida, the Gulf of Mexico and the Caribbean. Particular projects address events following the Deepwater Horizon oil spill, air-sea interaction associated with hurricanes, shelf dynamics, mixing, submesoscale variability, biological-physical interactions in ecosystems, coral reef studies and the Everglades Restoration. The research involves high-resolution numerical modeling, experimental studies and data assimilation.

Clouds, Aerosol, Precipitation, and Radiation Interactions (CAPRI)

The cloud microphysical processes important to the global energy balance occur at spatial and time scales of seconds and meters. MPO studies such processes with aircraft and surface-based remote sensing, in situ field measurements, and large-eddy simulations, and reconciles them with analyses done at the larger scales of satellites and regional and global climate models.

Satellite Remote Sensing

RSMAS hosts a real-time satellite reception and analysis facility. MPO is involved with retrieval algorithm development, validation and analysis of sea surface temperature, ocean color, sea surface topography and surface winds. MPO researchers also study observations of atmospheric phenomena such as clouds, aerosol, and water vapor. All these are analyzed in the context of climate research goals.

Master of Science (M.S.) Program

- M.S. in Meteorology and Physical Oceanography (MPO) (http://bulletin.miami.edu/graduate-academic-programs/marine-atmospheric-science/meteorology-physical-oceanography/meteorology-physical-oceanography-ms/)

Doctor of Philosophy (Ph.D.) Program

- Ph.D. in Meteorology and Physical Oceanography (MPO) (http://bulletin.miami.edu/graduate-academic-programs/marine-atmospheric-science/meteorology-physical-oceanography/meteorology-physical-oceanography-phd/)

MPO 602. Oceanography II (Physical). 2 Credit Hours.
The second section of the course core curriculum designed as an integrated and multidisciplinary view of ocean processes, covering the major disciplines of ma rine science and their applications to the study of the marine environment. To be taken in sequence with Oceanography I - Geological (MGG 501), Oceanography I II - Chemical (MAC 501), and Oceanography IV - Biological (MBF 502). This cours e is for non-MPO majors only.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

MPO 603. Physical Oceanography. 3 Credit Hours.
Introduction to properties of seawater, instruments and methods, heat budget, general ocean circulation, formation of water masses, dynamics of circulation, regional oceanography, waves, tides, and sea level. A mathematical and problem solving course for majors in MPO.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

MPO 606. Introduction to Ocean Remote Sensing. 3 Credit Hours.
This course is intended to provide undergraduate and graduate students with a complete overview of the most important ocean remote sensing techniques using passive (radiometers, cameras) and active instruments (mostly radar) on space- and airborne platforms, towers, ships, and land. PhD, MS, and MPS students who take this course can take the complementary course, OCE/MPO 707, in parallel or at a later time to gain further in-depth knowledge of the field. MPS students on the track Applied Remote Sensing are required to take both courses. Successful completion of undergraduate courses on calculus, statistics, and physics is desirable.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

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

MPO 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.

MPO 632. Broadcast Meteorology. 3 Credit Hours.
Students will learn the proper techniques involved in preparing and presenting a complete and professional weathercast with a heavy emphasis on communication skills, computer graphics, and on-camera delivery.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

MPO 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: Offered by Announcement Only.

MPO 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.

MPO 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 terms 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.

MPO 651. Introduction to Atmospheric Dynamics. 3 Credit Hours.
This course surveys the dynamics of atmospheric flow and the physically-grounded description and depiction of weather phenomena. It is intended to serve as core preparation for incoming PhD students whose research will be dynamical, while also serving as an accessible overview for students in other subdisciplines. For these reasons, it stresses phenomena and the essentials of our physical discourses about them (emphasizing useful approximations and lucid treatments), with enough exposure to the underlying full-complexity fundamentals to facilitate more advanced study in the future.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

MPO 652. Introduction to Atmospheric Physics. 3 Credit Hours.
The goal of this class is to develop an understanding of the fundamental physical processes governing cloud behavior and atmospheric radiative transfer, including atmospheric thermodynamics. The class will focus on processes with temporal scales of one day or less, and spatial scales of 1km or less, and will recognize the links to weather and climate, or through the student presentations. Students will learn about: cloud formation, lifetime, and dissipation, and how clouds interact with the aerosol, thermodynamic, and dynamic environments; about how clouds and clear skies interact with sunlight and infrared. This course is split into two sections: the first half will cover thermodynamics and cloud physics, and the second half will cover atmospheric radiation. Guest lectures by advanced graduate students and postdoctoral research associates will introduce students to current research areas.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

MPO 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.

MPO 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. Must have 2 years of both college physics and calculus, and some undergraduate coursework in atmospheric science is preferred.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

MPO 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.

MPO 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.

MPO 681. Special Topics. 1-4 Credit Hours.
Lectures, research projects or directed readings in special topics related to M eteorology and Physical Oceanography.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 682. Special Topics. 1-4 Credit Hours.
Lectures, research projects or directed readings in special topics related to M eteorology and Physical Oceanography.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 683. Special Topics. 1-4 Credit Hours.
Lectures, research projects or directed readings in special topics related to M eteorology and Physical Oceanography.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 684. Special Topics. 1-4 Credit Hours.
Lectures, research projects or directed readings in special topics related to M eteorology and Physical Oceanography.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 685. Special Topics. 1-4 Credit Hours.
Lectures, research projects or directed readings in special topics related to M eteorology and Physical Oceanography.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 707. Advanced Ocean Remote Sensing. 3 Credit Hours.
This course is intended to provide graduate students with additional in-depth knowledge on the topics covered by MPO/OCE 606. PhD, MS, and MPS students can take this course together with the introduction course or at a later time. MPS students on the track Applied Remote Sensing are required to take both courses. Successful completion of undergraduate courses on calculus, statistics, and physics and some experience in coding and/or data analysis on a computer is desirable. A laptop computer is required to participate in image analysis exercises and some homework assignments.
Prerequisite/Co-requisite: MPO 606 Or OCE 606.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

MPO 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-geos trophic waves.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

MPO 712. Large Scale Ocean Circulation: Models and Observations. 3 Credit Hours.
Course topics include theoretical models of the oceanic current systems, wind-driven and thermohaline circulation, effects of bottom topography, and lateral bounding.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

MPO 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.

MPO 716. Lagrangian Fluid Dynamics and Predictability. 3 Credit Hours.
The ash cloud produced by the eruption of Eyjafjallajokull in Iceland, the oil spill produced by the explosion of the Deepwater Horizon drilling rig in the Gulf of Mexico, and release of debris and radioactive contamination into the Pacific Ocean after the Fukushima nuclear reactor was hit by the Tohoku tsunami, are examples of events that have caused considerable impact to the environment. They all represent problems in Lagrangian ocean or atmospheric dynamics in which predicting where the material released into the environment will be transported by the ocean currents or winds is critical. A common approach to predict the outcome of an event like the above is to run an ocean or atmosphere circulation model simulations and then integrate the resulting velocity fields from a given release location to predict pollutant trajectories. An important drawback of such an approach is that the predictions are highly sensitive to small changes in the release time and location. Attempts to cope with the sensitivity to initial conditions include running several different models for the same scenario, but this typically leads to even larger distributions of advected tracers, hiding the key organizing structures of the flow. Improved understanding and forecasting requires novel notions and techniques capable of casting light on why material is transported the way it is by a given flow. The goal of this course is acquaint the student with a series of recent developments originated at the interface of nonlinear dynamics and fluid dynamics that have led to a number of novel such notions and techniques.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

MPO 721. Waves and Tides I. 3 Credit Hours.
The focus of this course is on the kinematics, dynamics and energetics of wave motions in the ocean and atmosphere from both theoretical and observational perspectives. We examine the internal wave spectrum ranging from the buoyancy frequency to the inertial frequency including the WKBJ scaling of the momentum by the buoyancy frequency. The IW spectrum often contains both the semidiurnal and diurnal tidal frequencies where the former is often referred to as internal tide that are excited along continental margins by barotropic tides. Within the context of normal modes, Kelvin and topographically Rossby waves are also present in this regime known as coastally trapped (also known as continental shelf waves). The course then goes into the equatorial wave guide that supports these motions (except for near-inertial motions). This is followed by the forced wave motions by atmospheric fronts and cyclones where Green's functions are introduced to derive analytical expressions for the 3-D current structure.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 724. Statistical Modeling of Geophysical Fields. 3 Credit Hours.
An advanced course in statistical modeling, analysis, and assimilation of geophysical data. Emphasis is placed on practical applications, computer software, and new nonstandard techniques.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

MPO 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.

MPO 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.

MPO 733. Marine Atmospheric Boundary Layer. 3 Credit Hours.
The marine atmospheric boundary layer plays a key role in the two-way interaction between the atmosphere and the ocean. This course will focus on describing and explaining marine atmospheric boundary layer structure and its evolution. This will include an emphasis on the cloud-topped boundary layer (marine stratocumulus) and the trade-wind boundary layer. Thus, in addition to turbulence, the physical processes considered in this treatment of the marine boundary layer will include shallow moist convection and radiation. The course will start with a basic description of the atmospheric boundary layer that will include a review of the relevant dynamics and thermodynamics. More advance topics will be covered in the second half of the course. Although the course will be a series of formal lectures, students will independently research selected topics, prepare a short review paper, and give an oral summary class.
Components: LEC.
Grading: GRD.
Typically Offered: Spring.

MPO 750. Coastal Ocean Circulation. 3 Credit Hours.
The oceanography of the continental margins are where tides, winds and waves interact on a spectrum of temporal and spatial scales in driving the shelf circulation from the shelf break to the inner shelf. The effects of baroclinicity, topography (and bottom stresses) will be explored in this course. We will highlight fundamental differences between wide versus narrow shelves, and those where boundary currents impact the shelf circulation such as the Loop Current on the west Florida shelf; Florida Current and Gulf Stream along the east coast; and the weaker and broader California Current along the US west coast.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 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: Fall.

MPO 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: Fall.

MPO 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.

MPO 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.

MPO 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.

MPO 770. Seminar in Meteorology and Physical Oceanography. 1 Credit Hour.
Oral presentation of research and special topics by students, faculty, and visiting scientists.
Components: SEM.
Grading: SUS.
Typically Offered: Fall & Spring.

MPO 771. Advanced Studies. 1-4 Credit Hours.
Supervised study in areas of special interest to graduate students.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 772. 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.

MPO 773. Advanced Studies. 1-4 Credit Hours.
Supervised study in areas of special interest to graduate students.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 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.

MPO 775. Advanced Studies. 1-4 Credit Hours.
Supervised study of special interest to graduate students.
Components: LEC.
Grading: GRD.
Typically Offered: Offered by Announcement Only.

MPO 776. Mesoscale Oceanography. 3 Credit Hours.
The course will present a current view of our understanding of ocean mesoscale variability, including its properties in different oceanic regimes, the dynamics governing its origin and development, and its overall role in the oceans and climate. Lectures will present material covering theory, observations (both in situ and satellite), and numerical model results. Students will learn basic concepts on ocean mesoscale processes and perspectives on current research topics from lectures, assignments and research papers.
Components: LEC.
Grading: GRD.
Typically Offered: Fall.

MPO 810. Master's Thesis. 1-6 Credit Hours.
The student working on their master's thesis enrolls for credit, in most departments not to exceed six, as determined by their advisor. Credit is not awarded until the thesis has been accepted.
Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.

MPO 820. Research in Residence. 1 Credit Hour.
Used to establish research in residence for the master's degree, after the student has enrolled for the permissible cumulative total in appropriate thesis research. Credit not granted. May be regarded as full-time residence as determined by the Dean of the Graduate School.
Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.

MPO 830. Doctoral Dissertation. 1-12 Credit Hours.
Required of all candidates for the Ph.D. The student will enroll for credit as determined by their advisor, but for not less than a total of 12 hours. Up to 12 hours may be taken in a regular semester, but not more than six in a summer session. Where a student has passed their (a) qualifying examinations, and (b) is engaged in an assistantship, they may still take the maximum allowable credit stated above.
Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.

MPO 850. Research in Residence. 1 Credit Hour.
Used to establish research in residence for the Ph.D., after the student has been enrolled for the permissible cumulative total in appropriate doctoral research. Credit not granted. May be regarded as full-time residence as determined by the Dean of the Graduate School.
Components: THI.
Grading: SUS.
Typically Offered: Fall, Spring, & Summer.