CLIMATE DYNAMICS (CLIM)

100 Level Courses

CLIM 101: *Global Warming: Weather, Climate, and Society.* 3 credits.
Survey of the scientific and societal issues associated with weather and climate variability and change. Examines physical phenomena observed in the Earth's weather and climate, providing sufficient scientific and technical background to enable students to critically examine arguments being discussed by policymakers and the public at large. Also reviews the current debate on climate change from a scientific point of view with a focus on those aspects that have the largest potential impact on global society.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Mason Core: Mason Core, Natural Science Overview, Encore: Sustainability (https://catalog.gmu.edu/mason-core/)

Specialized Designation: Green Leaf Related Course

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 102: *Introduction to Global Climate Change Science.* 4 credits.
The scientific basis of computer models that simulate past and present climate and predict future climate change; How complex models are built, tested, and interpreted to better understand physical, chemical, and biological processes; how uncertainty is managed. Students conduct laboratory experiments through an online interface and apply results to policy and planning. Designated a Green Leaf Course. Notes: Computer models are used in the lab.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Mason Core: Mason Core, Natural Science with Lab, Encore: Sustainability (https://catalog.gmu.edu/mason-core/)

Specialized Designation: Green Leaf Related Course

Recommended Prerequisite: Basic math skills (Geometry, Algebra).

Schedule Type: Laboratory, Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 103: *Global Warming: Weather, Climate, and Society Laboratory.* 1 credit.
Laboratory course accompanying CLIM 101. This course uses hands-on exercises to teach students about the causes and impacts of climate change, as well as adaptation and mitigation. Students will learn how to find and interpret climate data, analyze data related to climate adaptation and mitigation, quantify inequities in incidence of climate hazards, and communicate the elements of the scientific inquiry process.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Mason Core: Mason Core, Natural Science with Lab (https://catalog.gmu.edu/mason-core/)

Registration Restrictions:
Required Prerequisites: CLIM 101[C] or 101[XS].
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 111: *Introduction to the Fundamentals of Atmospheric Science.* 3 credits.
An overview of the Earth's atmosphere, its history, and the physical and chemical processes that determine its characteristics. The focus is on key concepts from thermodynamics, radiation, chemistry, and dynamics that are essential for understanding the state, variability, and long term evolution of the atmosphere, especially in the context of comparisons with other planetary atmospheres.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts. Equivalent to PHYS 111.
Mason Core: Mason Core, Natural Science Overview, Encore: Sustainability (https://catalog.gmu.edu/mason-core/)

Specialized Designation: Green Leaf Related Course

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 112: *Introduction to the Fundamentals of Atmospheric Science Lab.* 1 credit.
Laboratory course associated with PHYS 111/CLIM 111. Study of the Earth's atmosphere based on concepts taken from thermodynamics, radiation transport, chemistry, and dynamics.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts. Equivalent to PHYS 112.
Mason Core: Mason Core, Natural Science with Lab, Encore: Sustainability (https://catalog.gmu.edu/mason-core/)

Specialized Designation: Green Leaf Related Course

Registration Restrictions:
Required Prerequisites: (PHYS 111[*C], CLIM 111[*C], PHYS 111[XS] or CLIM 111[XS]).
[*] May be taken concurrently.
[C] Requires minimum grade of C.
[XS] Requires minimum grade of XS.

Schedule Type: Laboratory

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

300 Level Courses

CLIM 301: *Weather Analysis and Prediction.* 4 credits.
Large-scale behavior of mid-latitude weather systems. Includes coupling of synoptic motion to mesoscale processes that lead to significant weather events. Introduces the observational network, numerical weather models, and prediction. Laboratory portion gives practical experience in weather analysis, prediction, and technology currently used for visualization and analysis.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Recommended Prerequisite: MATH 113 or equivalent; and one of: CLIM/PHYS 111/112, or GGS 121.

Schedule Type: Laboratory, Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 312: *Physical Climatology.* 3 credits.
Quantitative description of nature and theory of the climate system, dynamics of atmosphere-ocean-land surface, internal interactions and response to external forcing, description of the climate record and simple climate models.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts. Equivalent to GGS 312.
Recommended Prerequisite: CLIM/PHYS 111/112 OR GGS 121; and PHYS 243,244, or permission of instructor.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 314: *Severe and Extreme Weather.* 3 credits.
Behavior of weather events ranging from small scale (e.g., thunderstorms and tornadoes) to mesoscale (e.g., fronts and hurricanes). Introduces the dynamical and physical processes, atmospheric boundary layer processes, and coupling between different spatial scales that create and shape severe and localized weather events. Designated a Green Leaf Course.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts. Equivalent to GGS 314.
Specialized Designation: Green Leaf Related Course

Recommended Prerequisite: MATH 113 or equivalent; CLIM/PHYS 111/112 or EOS 121 or GGS 121.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 319: *Air Pollution.* 3 credits.
Description of major types of air pollution and introduction to how their characteristics are influenced by interaction with the atmosphere. Topics include sources and distribution of pollution from local to global scales, effects of radiation and wind on pollution, modeling of plume dispersion, and pollution effects on climate. Designated a Green Leaf Course.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Specialized Designation: Green Leaf Related Course

Recommended Prerequisite: CLIM 111 or GGS 121.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 390: *Topics in Climate Research.* 1-4 credits.
Selected topics not covered in fixed content courses. May be included for credit by AOES majors in the 45 credits of courses required for BS degree.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree for a maximum 6 credits.
Specialized Designation: Topic Varies

Recommended Prerequisite: 15 credits of AOES courses within concentration.

Schedule Type: Independent Study

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

400 Level Courses

CLIM 401: *Midlatitude Synoptic Meteorology.* 3 credits.
This course teaches students how to apply dynamical concepts and methods in weather analysis and map interpretation. We first introduce the essential dynamical tools for synoptic meteorology, the quasigeostrophic theory, isentropic analysis and potential vorticity framework. Using these tools, we examine the midlatitude weather systems and phenomena, including extratropical cyclone, front, cold-air damming and winter storm. The concept of baroclinic instability is also introduced. Finally, basic procedure of numerical weather prediction and human forecasting processes are discussed.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Recommended Prerequisite: CLIM 301

Recommended Corequisite: CLIM 411

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 408: *Senior Research.* 3 credits.
Independent research under guidance of faculty member on a research project in numerical, experimental, observational, or theoretical atmospheric or climate-related research. A written report on the project is required. Notes: May be repeated with department permission.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree for a maximum 6 credits.
Mason Core: Mason Core, Writing Intensive in Major (https://catalog.gmu.edu/mason-core/)

Recommended Prerequisite: 15 credits of AOES courses within major.

Schedule Type: Research

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 409: *Research Internship.* 3 credits.
On-the-job experience for AOES majors in industry or government laboratories, including summer research programs. Students work in observational, experimental, or theoretical research, and prepare a written report at the end of the internship. Notes: May be repeated with department permission.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree for a maximum 6 credits.
Recommended Prerequisite: 75 credits. 15 credits of courses in major and permission of department.

Schedule Type: Independent Study

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 411: *Atmospheric Dynamics.* 3 credits.
Observational bases and fundamentals of fluid dynamic principle for understanding atmospheric motions across multiple spatial and temporal scales; covers basic conservation laws of mass, momentum, and energy; concepts of circulation and vorticity; balanced atmospheric flows, e.g. geostrophic wind and shear, thermal wind; quasi-geostrophic and isentropic potential vorticity analysis for mid-latitude cyclones and fronts.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Recommended Prerequisite: CLIM 111 and MATH 213, or permission of instructor.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 412: *Physical Oceanography.* 3 credits.
Reviews global patterns of temperature, salinity, currents and waves in the world's oceans and how these patterns influence marine biota, climate, and human activity. Introduces key concepts which explain physical features of the ocean ranging from microscopic turbulence to global circulation. Designated a Green Leaf Course.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts. Equivalent to GEOL 412.
Specialized Designation: Green Leaf Related Course

Recommended Prerequisite: MATH 113 or 115 and PHYS 160 or 253; or permission of instructor.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 429: *Atmospheric Thermodynamics.* 3 credits.
Thermodynamics of the atmosphere, properties of dry and moist air, air parcel as a thermodynamic system, atmospheric stability and convection, cloud formation and stability indices.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Recommended Prerequisite: CLIM 111, MATH 114 and PHYS 260; or permission of instructor.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 438: *Atmospheric Chemistry.* 3 credits.
Reviews fundamental chemical processes of the Earth's atmosphere including chemical cycles, thermodynamics, reaction kinetics, photochemistry, radiative balance, ozone chemistry and environmental issues, including air pollution, acid rain and global change. Includes some review of extraterrestrial atmospheric chemistry.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts. Equivalent to CHEM 438.
Recommended Prerequisite: CHEM 331 and 332 or permission of instructor.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 440: *Climate Dynamics.* 3 credits.
Structure, dynamics and thermodynamics of atmospheric and oceanic circulations that maintain the climate. Role of the large scale transport of energy, moisture and angular momentum. Relationships of large scale circulation to weather and weather extremes, and implications for past and future climates.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Recommended Prerequisite: MATH 213, MATH 214, and CLIM 411.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 456: *Introduction to Atmospheric Radiation.* 3 credits.
Provides fundamentals, physical understanding and quantitative analysis of radiative transfer in the atmosphere, discusses radiation processes-reflection, refraction, absorption, transmission, emission, and scattering and introduces tools for atmospheric radiative transfer. Provide students the basics for more advanced topics such as remote sensing or satellite meteorology.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Recommended Prerequisite: CLIM 111, MATH 114, and PHYS 260 or permission of instructor.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 470: *Numerical Weather Prediction.* 3 credits.
Concepts and techniques of numerical prediction of weather, including the numerical models used and the rationale for large suites of meteorological forecasts. Sources of errors in the forecast: errors in the initial conditions and in the numerical weather prediction models. Interpretation of model output.Offered by Atmospheric/Oceanic/Earth Sci. Limited to three attempts.
Recommended Prerequisite: MATH 213, MATH 214, and CLIM 411.

Schedule Type: Lecture

Grading:
This course is graded on the Undergraduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

500 Level Courses

CLIM 511: *Atmospheric Dynamics.* 3 credits.
Observational bases and fundamentals of fluid dynamic principles for understanding atmospheric motions across multiple spatial and temporal scales; covers basic conservation laws of mass, momentum, and energy; concepts of circulation and vorticity; balanced atmospheric flows, e.g. geostrophic wind and shear, thermal wind; quasi-geostrophic and isentropic potential vorticity analysis for mid-latitude cyclones and fronts.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: MATH 213 or equivalent.

Registration Restrictions:

Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 512: *Physical Oceanography.* 3 credits.
Course describes the global patterns of temperature, salinity, currents and waves in the world's oceans, and how these patterns influence marine biota, climate, and human activity. Course introduces key concepts which explain physical feature of the ocean ranging from microscopic turbulence to global circulation.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: MATH 113 or MATH 115; PHYS 160 or PHYS 243; or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

600 Level Courses

CLIM 601: *Midlatitude Synoptic Meteorology.* 3 credits.
This course teaches students how to apply dynamical concepts and methods in weather analysis and map interpretation. We first introduce the essential dynamical tools for synoptic meteorology, the quasigeostrophic theory, isentropic analysis and potential vorticity framework. Using these tools, we examine the midlatitude weather systems and phenomena, including extratropical cyclone, front, cold-air damming and winter storm. The concept of baroclinic instability is also introduced. Finally, basic procedure of numerical weather prediction and human forecasting processes are discussed.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Corequisite: CLIM 511

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 610: *Introduction to the Physical Climate System.* 3 credits.
Provides modern understanding of ocean, atmosphere, and land based on fundamental physical laws. Describes current climate and physical processes by which climate is maintained. Covers theoretical models of general circulation of atmosphere, including time mean and transient behavior. Describes basics of ocean circulation and interactions between ocean and atmosphere. Reviews past climate change, stratosphere and its interactions with troposphere, and role of land processes in modulating climate.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: BS or MS in mathematics or a physical science, or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 614: *Land-Climate Interactions.* 3 credits.
Interdisciplinary course providing detailed description of surface energy and water balance over land and radiative and turbulent transfer. Introduces numerical techniques for modeling land surface and applications in weather, climate, and hydrologic forecasting and simulation. Includes hands-on experience with land surface models in computer laboratory, including sensitivity experiments to reinforce theoretical concepts. Exposure to contemporary research through reading and reviewing seminal journal papers.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: BS or MS in mathematics or physical science, or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 631: *Urban Climate.* 3 credits.
Provides a coherent system to describe, study, and understand the essentials of urban (micro) climates. Explores the physical principals governing the creation of distinct urban climates. Explains ways the built environment interacts with the atmosphere over scales that extend from walls and roofs up to whole cities. Also considers the effects of weather and climate on the city.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:

This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 636: *Atmospheric Aerosols.* 3 credits.
Aerosols are small particles in the atmosphere which play an important role in cloud formation, the Earth's radiative balance, and human health. Societal aerosol emissions are a major driver of climate change. This course covers physical and chemical properties of atmospheric aerosols and their impacts on climate and health. Course topics include sources, size distribution, thermodynamics, effects on radiation, and interactions with clouds, and the importance of aerosols in health risks, biogeochemical effects, and proposed climate engineering.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: At least one course in chemistry, physics, environmental science, atmospheric, or climate science.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 670: *Earth System Modeling.* 3 credits.
An Earth system model is composed of models simulating the evolution of the atmosphere, ocean, cryosphere, biosphere, and other components. Course introduces the component models, their interactions, and how they are used to predict the behavior of weather and climate on time scales that range from hours to centuries. Students will learn technical and scientific skills necessary to run an Earth system model and evaluate its output.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: Computer programming experience

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 680: *Climate Data.* 3 credits.
How to process, analyze, and interpret environmental data for climate and related disciplines. Familiarizes students with software commonly used in atmospheric research and with techniques for working with large quantities of data. Examines mathematical tools for characterizing global physical data sets which vary in time and space, and applies the tools to observations and numerical model output.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: MATH 115 or an equivalent course and familiarity with a computer language.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 690: *Scientific Basis of Climate Change.* 3 credits.
A rigorous treatment of global warming, especially with regard to anthropogenic causes, based on the IPCC 4th Assessment Report "The Physical Science Basis". Topics include 1) Overview of observed climate, 2) Variability of climate, 3) Modeling of climate response to greenhouse gas forcing, 4) Greenhouse gases, chemistry, and aerosols, and 5) Projections of climate change and its societal impact.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: BS or MS in a natural science or engineering, or permission of instructor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy, Graduate, Junior Plus, Non-Degree or Senior Plus.

Enrollment is limited to Graduate, Non-Degree or Undergraduate level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

700 Level Courses

CLIM 700: *Climate Comprehensive Exam.* 1 credit.
Preparation for and completion of written comprehensive exam, on a climate-related subject, within AOES department. The exam is part of the degree requirements in lieu of writing a master's thesis. Instructor should be the chair of the examination committee. The exam committee will specify exam content.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree for a maximum 2 credits.
Recommended Prerequisite: At least 15 graduate credits, approved project proposal, and permission of major advisor or chair of the examination committee.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Independent Study

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 711: *Introduction to Atmospheric Dynamics.* 3 credits.
Covers basic conservation laws of mass, momentum, and energy and scaling analysis of equation of motion and thermodynamic equation. Discusses balanced flows in atmosphere, such as geostrophic wind and its vertical shear, and thermal wind relationship. Also explores circulation

and vorticity; role of atmospheric boundary layer in mass, momentum, and energy transfer; synoptic scale motions; and role of gravity and Rossby waves in controlling general circulation of atmosphere.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: BS or MS in mathematics or a physical science, or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 712: *Physical and Dynamical Oceanography.* 3 credits.
Introduces climatology and dynamics of oceans. Covers nature of seawater, heat, and salt budgets; general circulation of the ocean, including the Gulf Stream and thermohaline circulations; dynamics of wind-driven ocean circulation; and processes influencing biological and chemical behavior.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: BS or MS in mathematics or a physical science, or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 713: *Atmosphere-Ocean Interactions.* 3 credits.
Provides comprehensive observational and mechanistic understanding of El Nino and Southern Oscillation (ENSO) phenomena. Topics include observations and theories of seasonal and interannual changes in ocean circulation and temperature and interactions with atmosphere; equations of motion and theories of wind-driven circulation; mixed layer observations and theories; midlatitude and equatorial ocean waves; interannual variability and atmosphere-ocean coupling; and tropical oceanography and meteorology.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: CLIM 712 or 711 or equivalent, or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 715: *Numerical Methods for Climate Modeling.* 3 credits.
Foundation and theory of computational methods for atmosphere and ocean modeling, with special emphasis on finite-difference and spectral methods. Topics include accuracy, consistency, convergence and stability; time stepping schemes; nonlinear computational stability; energy and enstrophy conserving schemes for momentum equations; staggered and curvilinear grids; alternate vertical coordinate systems; implicit and split-explicit barotropic mode solution; pressure gradient errors and vorticity constraints; spectral methods for atmospheric models; and treatment of model physics.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: CLIM 712 or 711 or equivalent, or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 750: *Geophysical Fluid Dynamics.* 3 credits.
Introduces geophysical fluid dynamics, the study of rotating stratified flows. Covers hydrostatics; equations of motion, gravity wave dynamics, and stratified flow; effects of rotation, midlatitude dynamics, Rossby number and quasigeostrophic expansion; beta plane approximation; and equatorial Kelvin and Rossby waves.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: CLIM 711, or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 751: *Predictability and Prediction of Weather and Climate.* 3 credits.
Covers predictability and seamless prediction of weather and climate for timescales ranging from days to decades. Studies limitations to predictability due to chaos, and possible sources of predictability due to slowly varying surface boundary conditions produced by interactions among atmospheres, ocean and land system. Discusses predictability of droughts and floods, monsoons, ENSO, decadal variations and climate change.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Registration Restrictions:
Required Prerequisite: CLIM 711[B-].
[B-] Requires minimum grade of B-.

Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 752: *Ocean General Circulation.* 3 credits.
Description and theory of large-scale ocean circulation and how it affects climate. Focus is on ubiquitous flow structures such as gyres, equatorial currents, and meridional overturning cells. Examines how the circulation follows from wind and thermohaline forcing, as well as physical principles. The influence of the circulation on heat transport and climate variability is also discussed. Conceptual guideposts include barotropic gyres, Ekman cells, potential vorticity, western intensification, the interplay of gravity and the Earth's rotation, advective-diffusive balance, multiple flow states, and Rossby waves.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: CLIM 712 or 711 or equivalent, or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 753: *General Circulation of the Atmosphere.* 3 credits.
Overview and several theoretical perspectives of atmospheric transport of energy, moisture, and angular momentum, and how these processes fundamentally affect the climate on various time scales.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: CLIM 710 and CLIM 711.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 754: *Elements of the Tropical Climate System.* 3 credits.
Observations and dynamics of key processes of tropical weather and climate. Topics include: structure of the tropical atmosphere and ocean, convection, dynamics of tropical waves in the atmosphere and ocean, tropical intraseasonal variability, tropical the global monsoons, cyclones, and stratospheric quasi-biennial oscillation.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: CLIM 711.

Recommended Corequisite: CLIM 710.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 759: *Topics in Climate Dynamics.* 3 credits.
Covers selected topics in climate dynamics not covered in fixed-content courses. Notes: May be repeated for credit when offered with different content.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the term for a maximum 9 credits.
Specialized Designation: Topic Varies

Recommended Prerequisite: Permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 761: *Advanced Atmospheric Predictability and Prediction.* 3 credits.
Covers the theory and practice of predicting atmospheric circulation from daily weather to subseasonal weather regimes to seasonal climate. Discusses atmospheric data assimilation, the dynamics of rapidly amplifying modes, the role of large- scale instability and weather regime dynamics, and the role of boundary conditions. Students will design and carry out ensemble forecasts using a range of numerical models.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Registration Restrictions:
Required Prerequisites: (CLIM 711[B-] or 711[XS]) and (CLIM 751[B-] or 751[XS]).
[B-] Requires minimum grade of B-.
[XS] Requires minimum grade of XS.

Enrollment limited to students with a class of Advanced to Candidacy, Graduate or Non-Degree.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 762: *Statistical Methods in Climate Research.* 3 credits.
Introduction to a core set of statistical methods that have proven useful to modern climate and predictability research. Topics include detecting and attributing climate change, describing climate variability with empirical orthogonal functions, statistical forecasting with regression and time series models, and identifying coupled patterns of variability with canonical correlation analysis.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: Undergraduate level linear algebra and STAT 344 (or equivalent), or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 763: *Advanced Statistical Methods in Climate Research.* 3 credits.
Introduction to multivariate statistical techniques commonly used in climate science, with special emphasis on estimation in large dimensional spaces. Topics include: multivariate regression, canonical correlation analysis, predictable component analysis, field significance tests, data assimilation (especially the ensemble Kalman Filter), discriminant analysis, and multivariate detection and attribution of climate change.Offered by Atmospheric/Oceanic/Earth Sci. May not be repeated for credit.
Recommended Prerequisite: CLIM 762 or permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Lecture

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 796: *Directed Reading and Research.* 1-6 credits.
Reading and research on a specific topic in climate dynamics under the direction of a faculty member.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the term for a maximum 6 credits.
Specialized Designation: Topic Varies

Recommended Prerequisite: Admission into the climate dynamics doctoral program and permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Research

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 798: *Master's Climate Research Project.* 1-6 credits.
Research or literature-review project in climate science or related topic chosen and completed under the guidance of a faculty member. Proposal required before enrollment. Technical report acceptable to student's project committee required for completion.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree for a maximum 12 credits.
Recommended Prerequisite: At least 15 graduate credits, approved project proposal, and permission of major advisor or chair of the examination committee.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Thesis

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 799: *Master's Thesis in Climate.* 1-6 credits.
Research project in climate science or related topic chosen and completed under the supervision of a faculty member. Resulting thesis acceptable to student's committee and potentially publishable is required for completion.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree for a maximum 18 credits.
Recommended Prerequisite: Degree candidacy, thesis proposal approved by thesis committee, and permission of major advisor or instructor.

Registration Restrictions:
Enrollment is limited to Graduate or Non-Degree level students.

Students in a Non-Degree Undergraduate degree may **not** enroll.

Schedule Type: Thesis

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

900 Level Courses

CLIM 991: *Climate Dynamics Seminar.* 1 credit.
Presentations in climate dynamics field by Mason faculty and invited speakers. Notes: A maximum of 3 credits may be applied toward the climate dynamics PhD.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree.
Registration Restrictions:
Enrollment is limited to Graduate level students.

Schedule Type: Seminar

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 996: *Doctoral Reading and Research.* 1-6 credits.
Reading and research on a specific topic in climate dynamics under the direction of a faculty member.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the term for a maximum 6 credits.
Specialized Designation: Topic Varies

Recommended Prerequisite: Admission into the climate dynamics doctoral program and permission of instructor.

Registration Restrictions:
Enrollment is limited to Graduate level students.

Schedule Type: Research

Grading:
This course is graded on the Graduate Special scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 997: *Doctoral Qualification.* 3 credits.
Students develop a project that demonstrates their potential to do scientific research. Each student either proposes a research project, or submits an original manuscript that is suitable for a peer-reviewed scientific journal in the subject area of Climate Dynamics. Grading is based on an oral presentation and written work.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree for a maximum 6 credits.
Recommended Prerequisite: Permission of Instructor

Registration Restrictions:

Enrollment limited to students with a class of Advanced to Candidacy or Graduate.

Schedule Type: Independent Study

Grading:
This course is graded on the Graduate Regular scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 998: *Doctoral Dissertation Proposal.* 1-12 credits.
Covers development of research proposal under guidance of dissertation director and doctoral committee. Proposal forms basis for climate dynamics doctoral dissertation. Notes: Course may be repeated, but no more than 12 credits of CLIM 998 may be applied to doctoral degree requirements.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree.
Recommended Prerequisite: Doctoral standing and permission of advisor.

Registration Restrictions:
Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science college.

Schedule Type: Dissertation

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)

CLIM 999: *Doctoral Dissertation.* 1-12 credits.
Doctoral dissertation research under direction of dissertation director. Notes: May be repeated, but no more than 24 credits total in CLIM 998 and 999 may be applied to doctoral degree requirements.Offered by Atmospheric/Oceanic/Earth Sci. May be repeated within the degree.
Recommended Prerequisite: Admission to doctoral candidacy and permission of advisor.

Registration Restrictions:
Enrollment limited to students with a class of Advanced to Candidacy.

Enrollment is limited to Graduate level students.

Enrollment limited to students in the College of Science college.

Schedule Type: Dissertation

Grading:
This course is graded on the Satisfactory/No Credit scale. (https://catalog.gmu.edu/policies/academic/grading/)