ATM F425  Physical Hydrometeorology
3 Credits
Offered As Demand Warrants
Explores hydrometeorological processes, presents how to apply analysis
techniques/skills to solve fundamental hydrometeorological questions
(e.g. fire weather forecasting, drought forecasting, water resource
management, flood forecasting). Subjects covered are hydrographs, radar
images, meteograms, lysimeter, near-surface meteorology, surface energy
and water budgets, stream response, groundwater, drought-indices,
observational errors.
Prerequisites: ATM F401.
Stacked with ATM F625.
Special Notes: Recommended 400-level Physics, Calculus I to III.
Lecture + Lab + Other: 3 + 0 + 0

ATM F433  Atmospheric Remote Sensing
3 Credits
Offered Fall Odd-numbered Years
The course focuses on the physical principles of remote sensing and how
atmospheric measurements are made with passive and active techniques
from ground-, air- and satellite-based platforms. The course explores
principles of absorption, emission and scattering. Students work with
remote sensing data and explore specific techniques of interest to them.
Prerequisites: ATM F401 (may be taken concurrently).
Stacked with ATM F633.
Lecture + Lab + Other: 3 + 0 + 0

ATM F444  Weather Analysis and Forecasting
3 Credits
Offered Spring Even-numbered Years
Weather systems and the techniques used to understand and predict
their behavior. Topics include atmospheric observations, synoptic
analysis techniques, satellite image interpretation, kinematics, fronts
and frontogenesis, life cycles of extratropical cyclones, mesoscale
phenomena, numerical weather prediction and interpretation of forecast
products.
Prerequisites: ATM F401; ATM F445.
Stacked with ATM F644.
Lecture + Lab + Other: 3 + 0 + 0

ATM F445  Atmospheric Dynamics
3 Credits
Offered Fall Even-numbered Years
Examination of the fundamental forces and basic conservation laws
that govern the motion of the atmosphere. Topics include momentum,
continuity equations, circulation, vorticity, thermodynamics, the planetary
boundary layer and synoptic scale motions in mid-latitudes.
Prerequisites: ATM F401 (may be taken concurrently).
Stacked with ATM F645.
Lecture + Lab + Other: 3 + 0 + 0

ATM F446  Atmospheric Dynamics II: Climate Dynamics
3 Credits
Offered Spring Odd-numbered Years
Continuation of ATM F445/ATM F645. Includes geophysical fluid
dynamics as applied to the atmosphere. Topics include linear
perturbation theory, energy balance, kinetic energy cycle, dynamics
of zonally symmetric and varying flow, and tropical dynamics. g., C++,
FORTRAN, R, NCL).
Prerequisites: ATM F445; Senior Standing.
Recommended: experience with coding tools (e.
Stacked with ATM F646.
Lecture + Lab + Other: 3 + 0 + 0
ATM F456  Climate and Climate Change  
3 Credits  
Offered Fall Odd-numbered Years  
The climate of planet Earth and its changes with time. Radiative fluxes, greenhouse effects, energy budget, hydrological cycle, the atmospheric composition and climatic zones. Physical and chemical reasons for climatic change.  
Prerequisites: Any 400 level Physics or Chemistry course or ATM F401; basic computer skills.  
Stacked with ATM F656.  
Lecture + Lab + Other: 3 + 0 + 0

ATM F478  Mesoscale Dynamics  
3 Credits  
Offered As Demand Warrants  
A comprehensive explanation of mesoscale air motions — their phenology, basic physics and mechanisms, why they build and how mesoscale motions interact with the micro and large scale. Classical and non-classical mesoscale circulations, super cell, single and multiple cell thunderstorm dynamics and tornado formation. Special Note: Recommend 400-level physics, calculus I to III.  
Prerequisites: ATM F401.  
Stacked with ATM F678.  
Lecture + Lab + Other: 3 + 0 + 0

ATM F480  Climate Change Processes: Past, Present, Future  
4 Credits  
Offered Fall Odd-numbered Years  
This ‘synthesis’ course for Geography, NRM, or Natural Sciences undergraduates provides literacy in the rapidly developing field of climate-change science. Students will gain an understanding of climate dynamics and Earth’s climate history and will be trained to critically evaluate the validity of paleoclimatic reconstructions and climate-model predictions.  
Prerequisites: Junior or senior standing in major; ATM F401, GEOS F315, MSL F419 or MSL F481.  
Cross-listed with GEOS F480.  
Stacked with ATM F680, GEOS F680.  
Lecture + Lab + Other: 4 + 0 + 0

ATM F488  Undergraduate Research  
1-3 Credits  
Advanced research topics from outside the usual undergraduate requirements.  
Recommended: A substantial level of technical/scientific background.  
Lecture + Lab + Other: 0 + 0 + 0

ATM F601  Introduction to Atmospheric Sciences  
3 Credits  
Offered Fall  
Fundamentals of atmospheric science. Includes energy and mass conservation, internal energy and entropy, atmospheric water vapor, cloud microphysics, equations of motion, hydrostatics, phase oxidation, heterogeneous chemistry, the ozone layer, fundamentals of biogeochemical cycles, solar and terrestrial radiation and radiative-convective equilibrium. Also includes molecular, cloud and aerosol absorption and scattering.  
Prerequisites: Graduate standing.  
Cross-listed with CHEM F601.  
Stacked with ATM F401.  
Lecture + Lab + Other: 3 + 0 + 0

ATM F606  Atmospheric Chemistry  
3 Credits  
Offered Spring Odd-numbered Years  
Chemistry of the lower atmosphere (troposphere and stratosphere) including photochemistry, kinetics, thermodynamics, box modeling, biogeochemical cycles and measurement techniques for atmospheric pollutants; study of important impacts to the atmosphere which result from anthropogenic emissions of pollutants, including acid rain, the “greenhouse” effect, urban smog and stratospheric ozone depletion.  
Prerequisites: ATM F601.  
Cross-listed with CHEM F606.  
Stacked with CHEM F406.  
Lecture + Lab + Other: 3 + 0 + 0

ATM F610  Analysis Methods in Meteorology and Climate  
3 Credits  
Offered Spring Odd-numbered Years  
Introduction to standard analysis topics in Atmospheric Sciences, including basic aggregate stats, time series work, eigenmode analysis, mixed models, and extreme value analysis. Focus on manipulation of very large data sets, especially weather/climate model output. Hands-on instruction in supporting computer topics. Student presentations will be emphasized.  
Prerequisites: ATM F601; graduate standing.  
Recommended: Basic computer and mathematical knowledge to analyze and plot data.  
Lecture + Lab + Other: 3 + 0 + 0

ATM F613  Atmospheric Radiation  
3 Credits  
Offered Fall Odd-numbered Years  
Atmospheric radiation including the fundamentals of blackbody radiation theory and radiative properties of atmospheric constituents. Discussion of gaseous absorption including line absorption, broadening effects and radiative transfer. Includes scattering, radiative properties of clouds and radiation climatology.  
Prerequisites: ATM F601 (may be taken concurrently); graduate standing.  
Cross-listed with PHYS F613.  
Stacked with ATM F413; PHYS F413.  
Lecture + Lab + Other: 3 + 0 + 0
ATM F615  Cloud Physics
3 Credits
Offered Spring Even-numbered Years
Basic properties of condensed water vapor in the atmosphere. Formation and behavior of clouds including atmospheric aerosols, nucleation and growth of water droplets and ice crystals, the development of precipitation, nature of mixed-phase (water and ice) clouds, radiative transfer and experiments using AFARS Lidar, Microwave Radiometer and Satellite Remote sensing.
Prerequisites: ATM F601; graduate standing.
Stacked with ATM F415.
Lecture + Lab + Other: 3 + 0 + 0

ATM F620  Climate Journal Club Seminar
1 Credit
Offered Spring
The "Climate Group" is an informal meeting for researchers and graduate students. The seminars alternate between progress reports on ongoing research and journal club contributions. The main interests articles, formal and informal presentation by locals and visitors will be on the agenda. Participating students will be exposed to a free format discussion of modern ideas in climate related disciplines. All students are encouraged to contribute and students taking the course for credit are required to lead the discussion for one session. This may include the presentation of a research plan/results, or a discussion of a journal article. Students will be graded on at least one presentation and participation in the class.
Prerequisites: Graduate standing.
Lecture + Lab + Other: 1 + 0 + 0

ATM F621  Introduction to Computational Meteorology
1 Credit
Offered Fall
Introduces the basic knowledge on how to apply software related to atmospheric sciences problems. This includes UNIX/LINUX, FORTRAN90, NCL, Python, MATLAB and how to read data-formats (e.g., NetCDF files, grib-files, etc) for climate and remote sensing datasets. Students will learn how to run a given software and produce software modifications.
Prerequisites: Graduate standing.
Lecture + Lab + Other: 1 + 0 + 0

ATM F625  Physical Hydrometeorology
3 Credits
Offered As Demand Warrants
Explores hydrometeorological processes, presents how to apply analysis techniques/skills to solve fundamental hydrometeorological questions (e.g. fire weather forecasting, drought forecasting, water resource management, flood forecasting). Subjects covered are hydrographs, radar images, meteorograms, lysimeter, near-surface meteorology, surface energy and water budgets, stream response, groundwater, drought-indices, observational errors.
Prerequisites: ATM F401.
Stacked with ATM F425.
Special Notes: Recommended 400-level Physics, Calculus I to III.
Lecture + Lab + Other: 3 + 0 + 0

ATM F631  Environmental Fate and Transport
3 Credits
Offered Spring Even-numbered Years
Examination of the physical properties that govern the behavior, fate and transport of contaminants released into the environment. Topics include air-water partitioning and exchange, organic solvent-water partitioning, diffusion, sorption, chemical and biological transformation reactions, and modeling concepts.
Cross-listed with CHEM F631.
Lecture + Lab + Other: 3 + 0 + 0

ATM F633  Atmospheric Remote Sensing
3 Credits
Offered Fall Odd-numbered Years
The course focuses on the physical principles of remote sensing and how atmospheric measurements are made with passive and active techniques from ground-, air- and satellite-based platforms. The course explores principles of absorption, emission and scattering. Students work with remote sensing data and explore specific techniques of interest to them.
Prerequisites: ATM F401 or ATM F601; graduate standing.
Stacked with ATM F433.
Lecture + Lab + Other: 3 + 0 + 0

ATM F644  Weather Analysis and Forecasting
3 Credits
Offered Spring Even-numbered Years
Weather systems and the techniques used to understand and predict their behavior. Topics include atmospheric observations, synoptic analysis techniques, satellite image interpretation, kinematics, fronts and frontogenesis, life cycles of extratropical cyclones, mesoscale phenomena, numerical weather prediction and interpretation of forecast products.
Prerequisites: ATM F401; ATM F645.
Stacked with ATM F444.
Lecture + Lab + Other: 3 + 0 + 0

ATM F645  Atmospheric Dynamics
3 Credits
Offered Fall Even-numbered Years
Examination of the fundamental forces and basic conservation laws that govern the motion of the atmosphere. Topics include momentum, continuity equations, circulation, vorticity, thermodynamics, the planetary boundary layer and synoptic scale motions in mid-latitudes.
Prerequisites: ATM F601 (may be taken concurrently); graduate standing.
Stacked with ATM F445.
Lecture + Lab + Other: 3 + 0 + 0

ATM F646  Atmospheric Dynamics II: Climate Dynamics
3 Credits
Offered Spring Odd-numbered Years
Continuation of ATM F445/ATM F645. Includes geophysical fluid dynamics as applied to the atmosphere. Topics include linear perturbation theory, energy balance, kinetic energy cycle, dynamics of zonally symmetric and varying flow, and tropical dynamics. g., C++, FORTRAN, R, NCL).
Prerequisites: ATM F645; Graduate standing in Physics, Oceanography, Engineering, Natural Sciences, Atmospheric Sciences.
Recommended: experience with coding tools (e.
Stacked with ATM F446.
Lecture + Lab + Other: 3 + 0 + 0
ATM F647  
**Fundamentals of Geophysical Fluid Dynamics**
3 Credits
Offered Fall Odd-numbered Years
Introduction to the mechanics of fluid systems, the fundamental processes, Navier-Stokes' equations in rotating and stratified fluids, kinematics, conservation laws, vortex motion, irrotational flow, laminar flow, boundary layer phenomena, waves, instabilities, turbulent flows and mixing.
**Prerequisites:** Graduate standing.
**Cross-listed with:** PHYS F647.
**Lecture + Lab + Other:** 3 + 0 + 0

ATM F656  
**Climate and Climate Change**
3 Credits
Offered Fall Odd-numbered Years
The climate of planet Earth and its changes with time. Radiative fluxes, greenhouse effects, energy budget, hydrological cycle, the atmospheric composition and climatic zones. Physical and chemical reasons for climatic change.
**Prerequisites:** Graduate standing; calculus, physics or related courses at F400-level, basic computer skills.
**Recommended:** ATM F601 or ATM F401; basic computer knowledge to plot and analyze climate data.
**Stacked with:** ATM F456.
**Lecture + Lab + Other:** 3 + 0 + 0

ATM F658  
**Air-sea Interactions**
3 Credits
Offered Spring Even-numbered Years
Course covers the basics processes governing air-sea interactions at different temporal and spatial scales including; transfer of heat and momentum through air-sea surface, interactions of atmospheric and oceanic mixed layers, important examples of air-sea interactions; i.e. El Niño and interactions between high-latitude atmosphere and ocean.
**Prerequisites:** ATM F601; graduate standing.
**Lecture + Lab + Other:** 3 + 0 + 0

ATM F662  
**Numerical Modeling and Parameterization Methods**
3 Credits
Offered Spring Even-numbered Years
Construction of models from fundamental equations and the necessity of parameterizations. Simplification and discretization of equations, numerical methods, model-grids, analytical modeling, boundary and initial conditions, parameterizations and evaluation of model results. Scale-dependency, limitations of parameterizations and coupled modeling are elucidated. Students apply and code aspects of models themselves.
**Prerequisites:** Graduate standing; calculus, physics or related F400-level basic computer skills.
**Recommended:** ATM F601; basic knowledge in Fortran and UNIX/LINUX.
**Lecture + Lab + Other:** 3 + 0 + 0

ATM F673  
**Micrometeorology with Focus on Subarctic and Arctic Ecosystems**
3 Credits
Offered Fall Even-numbered Years
This course provides a comprehensive explanation of micrometeorology, physical mechanisms, measurement procedures and methods. The course focuses on subarctic and arctic ecosystems. Students receive training in eddy-covariance data processing for ecosystem fluxes computation. The course is oriented to students of biology and wildlife, natural resources and environmental sciences and engineering.
**Prerequisites:** Graduate standing.
**Stacked with:** ATM F473.
**Lecture + Lab + Other:** 3 + 0 + 0

ATM F678  
**Mesoscale Dynamics**
3 Credits
Offered As Demand Warrants
A comprehensive explanation of mesoscale air motions – their phenology, basic physics and mechanisms, why they build and how mesoscale motions interact with the micro and large scale. Classical and non-classical mesoscale circulations, super cell, single and multiple cell thunderstorm dynamics and tornado formation.
**Prerequisites:** Recommend 400-level physics, calculus I to III.
**Lecture + Lab + Other:** 3 + 0 + 0