METR-METEOROLOGY

METR 1003 Introduction to the Atmospheric Sciences 3 Credit Hours
Prerequisite: Math 1523 or higher or concurrent enrollment in Math 1823 or concurrent enrollment in Math 1914. An introduction to the field of atmospheric science, with a focus on concepts that can be understood using algebra. Periodic presentations from different professional atmospheric scientists introduce career options, challenges, and opportunities in the atmospheric sciences. Required of all meteorology majors during their first year of residence. (F)

METR 1014 Introduction to Weather and Climate 4 Credit Hours
For non-science majors. A descriptive study of both short-term and long-term atmospheric phenomena, evenly divided between: (1) the structure and processes in the atmosphere that affect our every-day weather; and (2) climate and causes of climate change. This course does not count for major credit in the School of Meteorology. Laboratory (F, Sp) [II-NSL].

METR 1034 Native Science and Earth Systems of North America 4 Credit Hours
(Crosslisted with GEOL 1034) Examines Earth systems of North America using both indigenous and Western perspectives, and an Earth science approach. This team-taught course will utilize a combination of geology, geography, meteorology, and Native American sciences, as expressed through the use of art. (Sp) [II-NSL].

METR 1111 Orientation to Professional Meteorology 1 Credit Hour
Prerequisite: Mathematics 1503 or higher. Required of all Meteorology majors during their first year of residence. Introduction to the School of Meteorology and its curriculum, faculty and staff. Presentations from different professional meteorologists introduce career options, challenges and opportunities in meteorology. (F)

METR 1313 Introduction to Programming for Meteorology 3 Credit Hours
Prerequisite: Math 1523 or equivalent, or concurrent enrollment. Introduction to the design and implementation of computer programs using the Python programming language. Emphasis on working with simple data sets. (F, Sp, Su)

METR 2004 Atmospheric Circulations 4 Credit Hours
Prerequisite: Grade of C or better in MATH 1914 (or MATH 2423), PHYS 2514, METR 1003, CHEM 1315, and METR 1313 (or CS 1321, 1323, or 1324). Co-requisites: MATH 2924 (or MATH 2433), PHYS 2524. Introduction to the application of mathematical techniques and physical principals to key atmospheric processes and phenomena, with a focus on stability, moisture, synoptic-scale flows, convection, boundary layer meteorology, and climate change. The course seeks to create a foundation of critical thinking and problem solving for subsequent classes in meteorology. Required of all meteorology majors during their second year of residence. (F)

METR 2011 Introduction to Meteorology I Laboratory 1 Credit Hour
Prerequisite: Grade of C or better in Math 1823 or 1914; corequisite: METR 2013, Math 2423 or 2924 and Physics 2514 or 1205. Reinforces the theoretical concepts provided in the counterpart lecture course Meteorology 2013, which introduces students to important phenomena and physical processes that occur in the earth's atmosphere. Through a series of laboratory exercises, students will learn the basic concepts and tools that are used to study atmospheric problems. Special emphasis will be placed on developing information technology and computational skills. (F, Sp) [II-NSL].

METR 2013 Introduction to Meteorology I 3 Credit Hours
Prerequisite: Grade of C or better in Math 1823 or 1914; corequisite: METR 2011, Math 2423 or 2924, Physics 2514 or 1205. Introduces students to important phenomena and physical processes that occur in earth's atmosphere, as well as to the basic concepts and instruments used to study atmospheric problems. Focuses on atmospheric radiation, thermodynamics, moisture, stability, clouds, and precipitation. (F, Sp) [II-NS].

METR 2021 Introduction to Meteorology II Laboratory 1 Credit Hour
Prerequisite: Grade of C or better in METR 2011 or 2014, 2013, MATH 2423 or 2924, and PHYS 2514 or 1205; corequisite: METR 2023, MATH 2433 or 2934, and PHYS 2524 or 1215. Reinforces the theoretical concepts provided in the counterpart lecture course Meteorology 2023, which introduces students to important phenomena and physical processes that occur in the earth's atmosphere. Through a series of laboratory exercises, students will learn the basic concepts and tools that are used to study atmospheric problems. Special emphasis will be placed on developing information technology and computational skills. The laboratory exercises target the topics covered in the lecture component. (Sp, Su)

METR 2023 Introduction to Meteorology II 3 Credit Hours
Prerequisite: Grade of C or better in METR 2013, 2011 or 2014, MATH 2423 or 2924, and PHYS 2514 or 1205; corequisite: METR 2021, MATH 2433 or 2934, and PHYS 2524 or 1215. Introduces students to important phenomena and physical processes that occur in earth's atmosphere. Students will learn the basic concepts and instruments used to study atmospoheric problems. Part II of the introduction to meteorology sequence focuses on atmospheric dynamics, wind systems of different origin and scale, and thunderstorms. It also addresses boundary layer meteorology, air pollution, forecasting and climate change. (Sp, Su)

METR 2213 Physical Meteorology I:Thermodynamics 3 Credit Hours
Prerequisite: C or better in PHYS 2524, MATH 2924 or MATH 2433, and METR 2004; Corequisite: MATH 2443 or MATH 2934; majors only. This course introduces the physical processes associated with atmospheric composition, basic radiation and energy concepts, the equation of state, the zeroth, first, and second law of thermodynamics, the thermodynamics of dry and moist atmospheres, thermodynamic diagrams, statics, and atmospheric stability. (F, Sp)

METR 2603 Severe and Unusual Weather 3 Credit Hours
Provide non-majors and majors a detailed descriptive account of the physical processes important in the formation of various severe and unusual weather phenomena including: thunderstorms, tornadoes, hail storms, lightning, hurricanes, midlatitude snowstorms, lake effect snows, atmospheric optical effects, and global climate change. This course does not count for major credit in the School of Meteorology. (Irreg.) [II-NS].

METR 2613 Atmospheric In-Situ & Surface-Based Measurements 3 Credit Hours
Prerequisite: Grade of C or better in METR 1313 or CS 1321 or CS 1323 or CS 1324, METR 2004, MATH 2924 or MATH 2433, PHYS 2524 and PHYS 1311; Co-requisite: MATH 2443 or 2934; majors only. Regardless of which area of atmospheric science you are interested in, measurements of atmospheric variables will undoubtedly influence your work. In any area of science, it is observations of nature that lead to new theories and new understanding. In meteorology, we cannot hope to predict weather accurately unless we have sufficient knowledge of the current state of the atmosphere. (F, Sp)

METR 2970 Special Topics/Seminar 1-3 Credit Hours
Special Topics. 1 to 3 hours. May be repeated; maximum credit nine hours. Special topics course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research, and field projects. (Irreg.)

METR 3011 Practicum on Broadcast Software 1 Credit Hour
Prerequisite: sophomore standing. May be repeated; maximum credit three hours. In this course students will learn how to use and manage the VIPIR and OMNI systems made by Baron Services. This will be accomplished via forecasting exercises and other various assignments. (F, Sp)

METR 3113 Atmospheric Dynamics I: Intro to Atmospheric Kinematics/ Dynamics 3 Credit Hours
Prerequisite: Grade of C or better in METR 2004, MATH 2443 or 2934, PHYS 2524, and METR 1313 (or CS 1321, 1323, or 1324). Characterization of the atmosphere mathematically, the study of forces acting upon it, and approximations used. Topics include Newton's laws of motion; energy, equilibrium and stability; coordinate systems and forces; the equations of motion and simple force balances; and mass and energy conservation. (F)

METR 3123 Atmospheric Dynamics II: Theory of Atmospheric Flows 3 Credit Hours
Prerequisite: Grade of C or better in METR 3113 and MATH 3413. Continuation of the study of atmospheric dynamics and kinematics begun in Dynamics I. Topics include: natural coordinates, geostrophic wind, inertial flow, cyclostrophic flow, gradient wind, thermal wind, kinematics and dynamics of circulation and vorticity, viscosity, and stress; turbulence, structure, and dynamics of the atmospheric boundary line. (Sp)

METR 3213 Physical Meteorology I: Thermodynamics 3 Credit Hours
Prerequisite: grade of C or better in METR 2023 and 2021, MATH 2433, 2443 or 2934, PHYS 1215 or 2524, and METR 1313 or CS 1313 or CS 1323. This course introduces the physical processes associated with atmospheric composition, basic radiation and energy concepts, the equation of state, the zeroth, first and second law of thermodynamics for dry and moist atmospheres, thermodynamic diagrams, statics, and atmospheric stability. (F)

METR 3223 Physical Meteorology II: Cloud Physics, Atmos Electricity/ Optics 3 Credit Hours
Prerequisite: Grade of C or better in METR 2213, METR 3513, MATH 3413. Cloud and precipitation processes including the role of aerosols in cloud droplet and ice nucleation, growth of cloud particles into rain, snow, and hail by diffusion, coalescence, and cloud aggregation; the Clausius-Clapeyron equation; application of cloud physics in cloud electrification and optical phenomena in the atmosphere; concepts of weather radar. (Sp)

METR 3334 Principles of Research & Communication in Meteorology 4 Credit Hours
Prerequisite: Grade of C or better in METR 1313, METR 2213, METR 2613, and MATH 2934 (or MATH 2443). An introduction to and/or development of topical skills in computing, writing, and speaking. The course will be composed of short thematic projects on topics relevant to meteorology and the atmospheric sciences. The professional skills gained reflect those needed by meteorologists in government, academia and the private sector. Required of all meteorology majors during their third year of residence. (Sp)

METR 3440 Mentored Research Experience 3 Credit Hours
0 to 3 hours. Prerequisites: ENGL 1113 or equivalent, and permission of instructor. May be repeated; maximum credit 12 hours. For the inquisitive student to apply the scholarly processes of the discipline to a research or creative project under the mentorship of a faculty member. Student and instructor should complete an Undergraduate Research & Creative Projects (URCP) Mentoring Agreement and file it with the URCP office. Not for honors credit. (F, Sp, Su)

METR 3513 Atmospheric Chemistry in Weather and Climate 3 Credit Hours
Prerequisite: Grade of C or better in METR 2213. Advanced survey of atmospheric structure and composition, and introduction to chemical processes in the atmosphere. Groups of relevant trace species and their role in the atmosphere are identified. Additional topics include importance of and chemical processes associated with aerosols, and direct and indirect linkages between chemistry, weather, and climate. Required of all meteorology majors during their third year of residence. (F)

METR 3523 Managing for a Changing Climate 3 Credit Hours
(Crosslisted with GEOG 3523) Prerequisite: Junior or Senior standing. Provides an integrative understanding of the components of the climate system including the range of natural climate variability and external drivers of climate change, in addition to impacts of a changing climate on multiple sectors such as the economy, policy, ecosystems, and indigenous populations. (F) [II-NS].

METR 3543 Balloons, Barometers, and Ice Cores: History of Weather and Climate Science 3 Credit Hours
(Crosslisted with HSTM 3543) Prerequisite: Junior standing or completion of one other course in HSTM or permission of instructor. This course explores the history of meteorology and climate sciences from 1500 to the present. We investigate the role of science in humanity's relationship with weather and climate, the social and political contexts of weather sciences as they have changed over time, and contributions of these sciences to sustainability and survival on a rapidly warming planet. No science background required. (F) [IV-WC].

METR 3613 Meteorological Measurement Systems 3 Credit Hours
Prerequisite: Grade of C or better in METR 2023 and 2021, MATH 2433, 2443 or 2934, PHYS 1215 or 2524, and METR 1313 or CS 1313 or CS 1323. Introduces the physical principles of meteorological instruments, discusses static and dynamic sensor performance, and explores the concepts of meteorological instruments, and to identify sensor limitations and major error sources. Furthermore, basic procedures of data analysis will be discussed. Laboratory (F)

METR 3890 Meteorology Internship 1-3 Credit Hours
1 to 3 hours. Prerequisite: METR 1111 and permission of instructor. 1-3 hours. May be repeated; maximum credit 12 hours. This course provides a mechanism for students to receive credit for their internship experiences with the National Weather Service, TV stations, the private sector or any other kind of agency or institution which provides internship opportunities for Meteorology Majors. (F, Sp, Su)

METR 3960 Honors Reading 1-3 Credit Hours
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. Consists of topics designated by the instructor in keeping with the student's major program. Covers materials not usually presented in the regular courses. (F, Sp, Su)

METR 3970 Honors Seminar 1-3 Credit Hours
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. Projects covered vary. Deals with concepts not usually presented in regular coursework. (Irreg.)

METR 3980 Honors Research 1-3 Credit Hours
1 to 3 hours. Prerequisite: admission to Honors Program. May be repeated; maximum credit six hours. Provides an opportunity for the gifted Honors candidate to work at a special project in the student's field. (F, Sp, Su)

METR 3990 Independent Study 1-3 Credit Hours
1 to 3 hours. Prerequisite: permission of instructor and junior standing. May be repeated once with change of content. Independent study may be arranged to study a subject not available through regular course offerings. (F, Sp, Su)

METR 4013 Science at the Tropopause: Physics, Dynamics, & Chemistry of the Upper Troposphere/Lower Stratospher 3 Credit Hours
(Slashlisted with METR 5013) Prerequisite: Grade of C or better in both METR 2213 and METR 3113, or permission of instructor; Not open to Freshmen. A survey of the dynamics, physics, and chemistry of the UTLS. Topics will include basic characteristics of the UTLS, definition of the tropopause, dynamic principals of and theory used for the UTLS, stratosphere-troposphere exchange, and common analysis techniques for UTLS studies. Will gradually increase focus on process-level understanding and review key dynamic and physical features/ phenomena that impact the UTLS. No student may earn credit for both 4013 and 5013. (Sp)

METR 4023 Polar Meteorology 3 Credit Hours
(Slashlisted with METR 5023) Prerequisite: grade of C or better in MATH 3113 or MATH 3413, or permission by instructor. This course provides an introduction and overview to weather and climate of the Earth's polar regions. This includes the climatology, dynamics, and thermodynamics of Arctic and Antarctic atmospheres. Special topics of significance will include the polar boundary layer, sea ice, polar vortices, polar lows, and oceanic circulations. This course will develop and strengthen skills in teaching, research, and service. No student may earn credit for both 4023 and 5023. (Irreg.)

METR 4043 Urban Climatology 3 Credit Hours
(Slashlisted with METR 5043; Crosslisted with GEOG 4043) Prerequisite: Junior standing or departmental permission. This course provides an overview of urban climates based on a synthesis of modern scientific and applied research findings. The course covers a broad spectrum of topics such as urban airflow, radiation exchanges, urban energy balance, urban heat island, urban surface hydrology, air pollution, cities under global climate change, biometeorology, and sustainable urban design and planning. No student may earn credit for both 4043 and 5043. (Sp)

METR 4083 Developing Ethical and Responsible AI for Earth Sciences 3 Credit Hours
(Slashlisted with METR 5083) Prerequisite: grade of C or better in C S 4013/5013 or C S 4033/5033 or C S 5043; or permission of instructor. Ethics of developing Artificial Intelligence (AI) for Earth and environmental sciences (ES). Topics will include responsible conduct of research, ethical scientific conduct, ownership of ideas, algorithms and data, and ethics of developing AI for ES applications. Learning activities include active discussions and debates, writing, and projects. No student may earn credit for both 4083 and 5083. (Sp)

METR G4133 Atmospheric Dynamics III: Mid-Latitude Synoptic-Scale Dynamics 3 Credit Hours
Prerequisite: Grade of C or better in 3123 and 3223. Concepts from kinematics, dynamics and thermodynamics used to characterize synoptic-scale atmosphere, emphasis on quasi-geo strophic and baroclinic instability theory as basis for understanding extra-tropical weather systems including cyclones, fronts and jets. Linear theory is used to describe a variety of atmospheric waves and their role in synoptic-scale meteorology. (F)

METR G4233 Physical Meteorology III: Radiation and Remote Sensing 3 Credit Hours
Prerequisite: Graduate standing, or grade of C or better in METR 3123 and METR 3223. Fundamental principles of radiation; absorption and emission of radiation; solar and terrestrial radiation; radiative transfer and heating rates; surface and global energy balances; atmospheric general circulation; natural climate variations; greenhouse climate change; stratospheric ozone depletion. (F)

METR 4313 Statistical Meteorology 3 Credit Hours
(Slashlisted with METR 5313) Prerequisite: METR 1313 or CS 1313 or CS 1321 or CS 1323 or CS 1324; and MATH 2423 or MATH 2924; with grade of C or better; or permission of instructor. The role of probability and statistics in meteorology and climate: decision making, sampling, graphical presentation of data, resampling techniques, autocorrelation, confidence intervals, statistical power, and various regression models. Computational aspects using meteorology and climate data will be emphasized. No student may earn credit for both 4313 and 5313. (F)

METR 4323 Weather Simulation With Computers 3 Credit Hours
Prerequisite: METR 1313. The basics principles of computer programming for simulating and predicting fluid motion with computers. Applications range from idealized baroclinic instability to idealized tornado vortices. The FORTRAN and Python programming languages will be used. Prior programming experience is required, but not necessarily with these languages. (Irreg.)

METR 4330 Information Technology Skills for Meteorology 1-3 Credit Hours
(Slashlisted with 5330) Prerequisite: grade of C or better in CS 1313 or permission of instructor. May be repeated; maximum credit three hours. The use of computers and networks to process the information of meteorology. Workstation skills, computer operating systems, programming languages, the internet, computer graphics, analysis and display of meteorological data. No student may credit for both 4330 and 5330. (Irreg.)

METR 4403 Application of Meteorological Theory to Severe-Thunderstorm Forecasting 3 Credit Hours
(Slashlisted with METR 5403) Prerequisite: majors only; METR 4424 with a grade of B or better or permission of instructor. This course provides an opportunity to bridge the academia and operational forecasting realms and provide an opportunity for students to learn from experienced meteorologist-forecasters who have performed research on a variety of topics. No student may earn credit for both 4403 and 5403. (Sp)

METR G4424 Synoptic Meteorology Laboratory 4 Credit Hours
Prerequisite: Grade of C or better in 3123 and 3223. This course is a lecture/laboratory course designed to provide students a physical understanding of atmospheric principles. Students are challenged to explain theoretical concepts and to demonstrate a mastery in understanding various physical processes including the theory and practice of weather analysis and forecasting, surface and upper air analysis, fronts and wave cyclones, satellite meteorology, sounding analysis, thermodynamic diagram, cross sections, forecasting, NMC models, MOS, radar meteorology, and severe weather. Communications skills are emphasized. (F)

METR G4433 Mesoscale Meteorology 3 Credit Hours
Prerequisite: Grade of C or better in 4133, 4424. Structure and dynamics of convective and mesoscale phenomena including: mesoscale convective systems, severe thunderstorms, tornadoes, low-level jets, mountain waves and hurricanes. Discussion of the general behavior, characteristics, and dynamics of the formation and development of these phenomena, and the types of weather and hazards they produce. (Sp)

METR 4443 Introduction to Tropical Meteorology 3 Credit Hours
(Slashlisted with 5443) Prerequisite: senior standing in Meteorology or permission of instructor. Introduces students to the weather and climate of the tropics. Material presented will include an overview of tropical weather, basic physics of air-sea interaction and the attendant effects on tropical weather. No student may earn credit for both 4443 and 5443. (Irreg.)

METR 4523 Climate and the General Circulation 3 Credit Hours
Prerequisite: Grade of C or better in MATH 2443, MATH 3413, PHYS 2524, and METR 4233. Characterizes the climate of the Earth's atmosphere qualitatively and quantitatively, with a focus on large-scale dynamics and the general circulation. Applies the gained knowledge of the climate system and climate modeling to understand global climate change and climate variability in the past, present, and future. Required of all meteorology majors during their fourth year of residence. (Sp)

METR 4533 Earth's Past Climate 3 Credit Hours
(Slashlisted with METR 5533; Crosslisted with GEOL 4533) Prerequisite: senior or graduate standing, or permission of instructor. Explores earth's climate system, controls on climate change, and evolution of climate history through geologic time as deciphered from climate proxies. No student may earn credit for both 4533 and 5533. (F)

METR 4543 Global Climate Change 3 Credit Hours
(Slashlisted with METR 5543) Prerequisite: One of the following: METR 1014, METR 2013, METR 2603, METR 2903, CEES 1112, GEOG 1114, GEOG 1203, GEOG 3023, GEOL 1034, GEOL 1104, GEOL 1114, GEOL 2014, or permission or instructor. The Intergovernmental Panel on Climate Change assesses the scientific and socio-economic information relevant for understanding the risk of human-induced climate change. This interdisciplinary class will use readings, student-led presentations and roundtable discussions of the in-situ observations, as well as modeling of the atmosphere, oceans, ice, carbon, clouds and radiative forcing to understand the next 100-years of climate change. No student may earn credit for both 4543 and 5543. (Sp)

METR 4553 Climate and Renewable Energy 3 Credit Hours
(Slashlisted with METR 5553) Prerequisite: junior standing. Examines the science and technical aspects of solar, wind, hydro, and biomass power systems. Targets students interested in environmental science. Emphasis is on the key role of climate in determining where each of these systems is most likely to provide feasible alternatives to energy generated by fossil fuels. No student may earn credit for both 4553 and 5553. (Sp)

METR 4603 Advanced Observations for Lower Atmospheric Research 3 Credit Hours
(Slashlisted with METR 5603) Prerequisite: METR 2213 and METR 2613, or instructor permission. This course will examine the observation and operation principles behind a variety of research-grade instruments and the data they provide. Taught as a mix of lectures, instrument demonstrations, and data-focused projects, material presented focuses on modern, state-of-the-art instruments applied to current research problems emphasizing lower-atmospheric observations. Students use Python for processing, analysis, and visualization of real observed datasets. No student may earn credit for both 4603 and 5603. (F)

METR 4623 Radar Meteorology 3 Credit Hours
Prerequisite: grade of C or better in METR 2613 or METR 3613, Math 2433 or Math 2934. Principles of weather radar and storm observations including: radar system design, em wave propagation, radar equation for point and distributed targets, Rayleigh/Mie/Gan scattering, power spectrum, I&Q, moments of the power spectrum, ground clutter, attenuation, rainfall measurements using radar reflectivity and using polarization diversity radars, Doppler interpretation and analysis, polarimetric theory and applications, kinematics of of convective storms. (Sp)

METR G4633 Hydrometeorology 3 Credit Hours
(Slashlisted with METR 5633) Prerequisite: Grade of C or better in METR 3123, METR 3223 or permission of instructor. Interdisciplinary emphasis on mesoscale precipitation processes, applications of new hydrometeorological observing systems, and on the interactions between meteorology and hydrology during flood events. No student may earn credit for both 4633 and 5633. (Irreg.)

METR 4663 Radar Engineering 3 Credit Hours
(Crosslisted with ECE 4663; Slashlisted with 5663) Prerequisite: grade of C or better in Electrical and Computer Engineering 3613, or permission. Introduction to radar system designs and applications with emphasis on weather radar. Radar system architecture and their functionalities and limitations of subsystems are discussed. Theories of radar detection and estimation in a noisy and cluttered environment; existing technologies and advanced techniques to improve radar performance. No student may earn credit in both 4663 and 5663. (F)

METR 4693 Environmental Sampling Methods 3 Credit Hours
(Slashlisted with METR 5693; Crosslisted with PBIO and MBIO 4693) Prerequisite: diverse STEM background; permission of instructor; senior standing. The course gives students from diverse STEM backgrounds experience and knowledge of environmental sampling techniques, analysis of data generated, and interpretation of results in a scientific field outside their primary area of study. The multi-disciplinary structure helps students develop an understanding of different sampling techniques based on assumptions and perspectives on the environment at different spatial scales. No student may earn credit for both 4693 and 5693. (Sp)

METR 4713 Private Sector Meteorology 3 Credit Hours
Prerequisite: senior standing in Meteorology. An overview of private sector meteorology in the United States. Designed to build background knowledge, foster the use of higher-order analytical skills, and further develop communication and presentation skills. The course includes lectures, directed readings, visiting local private sector companies, interviews with practicing meteorologists, and the development of a portfolio about a private sector meteorological company. Students gain experience in applying their meteorological knowledge to a practical problem as might be encountered in professional practice. No student may earn credit for both 4713 and 5713. (Irreg.)

METR 4743 Applications of Weather Forecasting 3 Credit Hours
Prerequisite: METR 2013 or instructor permission. The course will focus on introducing students to various types of weather forecasts, and how those weather forecasts are created. (F, Sp)

METR 4753 Forecast and Warning Communication 3 Credit Hours
(Slashlisted with METR 5753) Prerequisite: Junior or Senior Standing. This course explores the fundamental theories related to the communication of weather and climate information. We will explore effective risk communication, including characteristics of the forecast, the audience, and the message that most effectively convey the information to multiple audiences. Guest speakers will share their expertise so students see the range of jobs that exist in the weather/climate information sphere. No student may earn credit for both 4753 and 5753. (Irreg.)

METR G4803 Selected Topics in Meteorology 3 Credit Hours
Prerequisite: permission of instructor. May be repeated with change of subject matter; maximum credit 12 hours. Topics may include aspects of atmospheric dynamics and severe-storm forecasting, experimental design, economic meteorology, weather modification, climate, radiation, aviation weather, etc. (Irreg.)

METR 4911 Senior Seminar (Capstone) 1 Credit Hour
Prerequisite: Grade of C or better in 3123, 3223. With 4922, satisfies Capstone course requirement. The instructor will guide senior meteorology majors through planning of a research project. Interdisciplinary topics are encouraged and library work will be required. Students will be paired with regular or adjunct faculty mentors. Senior doctoral students may serve as mentors with permission from the instructor. The result of 4911 will be a mini-proposal which will serve as a guide for the senior research project. In addition, the instructor may present professional skills useful during job search, early employment, and graduate school application and attendance. Note that METR 4922 should be taken following this course. (F, Sp) [V].

METR 4913 Senior Seminar 3 Credit Hours
Prerequisite: grade of C or better in 3113 and 3223. Satisfies the capstone course requirement. The instructor will guide senior meteorology majors on a research project. Interdisciplinary topics will be encouraged and library work is required. Students will complete written and oral presentations of a senior thesis. (F, Sp) [V].

METR 4922 Senior Seminar II (Capstone) 2 Credit Hours
Prerequisite: Grade of C or better in 3123, 3223, 4911. with 4911, satisfies the Capstone course requirement. The instructor will guide students as they follow the research plan established in the mini-proposal completed in METR 4911. Library work will continue to be required with development of research methodology and analysis of results. Students will continue to work with faculty (senior doctoral student) mentors. The culmination of the two-course Capstone sequence will be a written and oral presentation of the senior thesis. The skills learned in Capstone I and II will be useful whether the student is employed in academia, government, or the private sector. (F, Sp) [V].

METR 4960 Directed Readings 1-4 Credit Hours
1 to 4 hours. Prerequisite: good standing in University; permission of instructor and dean. May be repeated; maximum credit four hours. Designed for upper-division students who need opportunity to study a specific problem in greater depth than formal course content permits. (Irreg.)

METR 4970 Special Topics/Seminar 1-3 Credit Hours
1 to 3 hours. Prerequisite: Senior standing or permission of instructor. May be repeated; maximum credit nine hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research and field projects. (Irreg.)

METR 4990 Special Problems in Meteorology 1-4 Credit Hours
1 to 4 hours. Prerequisite: permission of instructor. May be repeated with change of subject matter. (F, Sp, Su)

METR 5004 Fundamentals of Atmospheric Science 4 Credit Hours
Prerequisite: graduate standing in a meteorology, physical science, or engineering program, MATH 3113 or MATH 3413 or permission of instructor. Provides a rigorous survey of the fundamental concepts in the atmospheric sciences relevant to weather, climate and atmospheric chemistry. The course is designed to provide sufficient background knowledge so that the students will be prepared to successfully undertake more specialized graduate coursework in meteorology. Graduate students in fields closely related to meteorology, such as radar engineering and hydrology, will also benefit from knowledge of these concepts. (F)

METR 5013 Science at the Tropopause: Physics, Dynamics, & Chemistry of the Upper Troposphere/Lower Stratospher 3 Credit Hours
(Slashlisted with METR 4013) Prerequisite: Graduate standing. A survey of the dynamics, physics, and chemistry of the UTLS. Topics will include basic characteristics of the UTLS definition of the tropopause, dynamical principals of and theory used for the UTLS, stratosphere-troposphere exchange, and common analysis techniques for UTLS studies. Will gradually increase focus on process-level understanding and review key dynamical and physical features/phenomena that impact the UTLS. No student may earn credit for both 4013 and 5013. (Sp)

METR 5023 Polar Meteorology 3 Credit Hours
(Slashlisted with METR 4023) Prerequisite: graduate standing in a meteorology or related discipline; grade of C or better in MATH 3113 or MATH 3413, or permission by instructor. This course provides an introduction and overview to weather and climate of the Earth's polar regions. This includes the climatology, dynamics, and thermodynamics of Arctic and Antarctic atmospheres. Special topics of significance will include the polar boundary layer, sea ice, polar vortices, polar lows, and oceanic circulations. This course will develop and strengthen skills in teaching, research, and service. No student may earn credit for both 4023 and 5023. (Irreg.)

METR 5043 Urban Climatology 3 Credit Hours
(Slashlisted with METR 4043; Crosslisted with GEOG 5043) Prerequisite: Graduate standing or departmental permission. This course provides an overview of urban climates based on a synthesis of modern scientific and applied research findings. The course covers a broad spectrum of topics such as urban airflow, radiation exchanges, urban energy balance, urban heat island, urban surface hydrology, air pollution, cities under global climate change, biometeorology, and sustainable urban design and planning. No student may earn credit for both 4043 and 5043. (Sp)

METR 5083 Developing Ethical and Responsible AI for Earth Sciences 3 Credit Hours
(Slashlisted with METR 4083) Prerequisite: graduate standing; grade of C or better in C S 4013/5013 or C S 4033/5033 or C S 5043; or permission of instructor. Ethics of developing Artificial Intelligence (AI) for Earth and environmental sciences (ES). Topics will include responsible conduct of research, ethical scientific conduct, ownership of ideas, algorithms and data, and ethics of developing AI for ES applications. Learning activities include active discussions and debates, writing, and projects. No student may earn credit for both 4083 and 5083. (Sp)

METR 5103 Boundary Layer Meteorology 3 Credit Hours
Prerequisite: 3113, Mathematics 3113. Transfer processes near the earth's surface, turbulence, the planetary boundary layer, air mass modification, fog formation, pollutant transport.

METR 5113 Advanced Atmospheric Dynamics I 3 Credit Hours
Prerequisite: Mathematics 4163 or permission of instructor. Basic fluid dynamics, equations of motion, vorticity dynamics, scale analysis, shallow water equations, linear wave dynamics, gravity waves, Rossby waves, quasi-geostrophic motions. (F)

METR 5223 Atmospheric Radiation 3 Credit Hours
Prerequisite: 3213, Mathematics 3113, or permission of instructor. Theory of radiative transfer, spectra of gaseous molecules, use of band models for radiative calculations, interaction of solar radiation with atmospheres, infrared radiative transfer in atmospheres, radiative cooling and heating, scattering, climate and radiation, remote sensing. (Sp)

METR 5233 Cloud and Precipitation Physics 3 Credit Hours
Prerequisite: 3223, Mathematics 3113. Development of thermodynamical relationships and generalized Clausius-Clapeyron equation, phase diagrams, atmospheric aerosols, review of hydrodynamics of flow past particles, collision and coalescence efficiency, theory of nucleation, precipitation growth, observations with radar, electrical state of the atmosphere. (F)

METR 5243 Atmospheric Electrodynamics 3 Credit Hours
Prerequisite: permission of instructor. Global electrical circuit, fair-weather electricity, storm electrification, charging mechanisms, electrical discharges, lightning, thunder, instrumentation and observing systems, meteorological applications.

METR 5303 Objective Analysis 3 Credit Hours
Prerequisite: METR 4133, MATH 3113 or MATH 3413, or equivalent. Introduction to techniques used in objective analysis of meteorological data; polynomial fitting; method of successive corrections; weighting functions; statistical methods; optimum interpolation; filter design; four-dimensional data assimilation. (F)

METR 5313 Statistical Meteorology 3 Credit Hours
(Slashlisted with METR 4313) Prerequisite: Graduate standing. The role of probability and statistics in meteorology and climate: decision making, sampling, graphical presentation of data, resampling techniques, autocorrelation, confidence intervals, statistical power, and various regression models. Computational aspects using meteorology and climate data will be emphasized. No student may earn credit for both 4313 and 5313. (F)

METR 5330 Information Technology Skills for Meteorology 1-3 Credit Hours
(Slashlisted with 4330) Prerequisite: Grade of C or better in Computer Science 1313 or permission of instructor. May be repeated; maximum credit three hours. The use of computers and networks to process the information of meteorology. Workstation skills, computer operating systems, programming languages, the Internet, computer graphics, analysis and display of meteorological data. No student may earn credit for both 4330 and 5330. (Irreg.)

METR 5344 Computational Fluid Dynamics I 4 Credit Hours
Prerequisite: 3113 or Engineering 3223; Engineering 3723; Mathematics 3123; permission of instructor. Application of fine difference, spectral, and semi-Lagrangian methods to multidimensional Newtonian fluid flow problems, including well-posedness, consistency, stability, convergence, accuracy, boundary conditions, conservation, grid systems, and filtering. In addition, code development practices and the use of high-performance vector and parallel supercomputers will be addressed.

METR 5403 Applications of Meteorological Theory to Severe-Thunderstorm Forecasting 3 Credit Hours
(Slashlisted with METR 4403) Prerequisite: graduate standing and department permission. This course provides an opportunity to bridge the academia and operational forecasting realms and provide an opportunity for students to learn from experienced meteorologist-forecasters who have performed research on a variety of topics. No student may earn credit for both 4403 and 5403. (Sp)

METR 5413 Advanced Synoptic Meteorology 3 Credit Hours
Prerequisite: 4133, 4424, 5113 or permission of instructor. Theory and application of quasi-geostrophic dynamics, Q-vectors and isentropic potential vorticity, diagnostic studies of mid-latitude synoptic-scale systems, mesoscale structure of precipitation, structure and dynamics of fronts and jets. (Sp)

METR 5433 Advanced Statistical Meteorology 3 Credit Hours
Prerequisite: senior standing or graduate standing and permission of instructor. Data analysis is a routine part of many types of research in the atmospheric sciences. As such, having the right set of tools and prowess on how to use those tools is an important part to understanding the statistical and dynamical behavior of the climate system. (F, Sp)

METR 5443 Introduction to Tropical Meteorology 3 Credit Hours
Prerequisite: graduate standing or permission of instructor. Introduces students to the weather and climate of the tropics. Material presented will include an overview of tropical weather, basic physics of air-sea interaction and the attendant effects on tropical weather. No student may earn credit for both 4443 and 5443. (Irreg.)

METR 5503 Climate Dynamics 3 Credit Hours
Prerequisite: 5113. Survey of past climates; climate variability; heat and water budgets of the atmosphere, oceans and land surfaces; the general circulation; climate modeling.

METR 5533 Earth's Past Climate 3 Credit Hours
(Slashlisted with METR 4533; Crosslisted with GEOL 5533) Prerequisite: senior or graduate standing, or permission of instructor. Explores earth's climate system, controls on climate change, and evolution of climate history through geologic time as deciphered from climate proxies. No student may earn credit for both 4533 and 5533. (F)

METR 5543 Global Climate Change 3 Credit Hours
(Slashlisted with METR 4543) Prerequisite: permission of instructor. The Intergovernmental Panel on Climate Change assesses the scientific and socio-economic information relevant for understanding the risk of human-induced climate change. This interdisciplinary class will use readings, student-led presentations and roundtable discussions of the in-situ observations, as well as modeling of the atmosphere, oceans, ice, carbon, clouds and radiative forcing to understand the next 100-years of climate change. No student may earn credit for both 4543 and 5543. (Sp)

METR 5553 Climate and Renewable Energy 3 Credit Hours
(Slashlisted with METR 4553) Prerequisite: Mathematics 1503. Examines the science and technical aspects of solar, wind, hydro, and biomass power systems. Targets students interested in environmental science. Emphasis is on the key role of climate in determining where each of these systems is most likely to provide feasible alternatives to energy generated by fossil fuels. No student may earn credit for both 4553 and 5553. (Sp)

METR 5603 Advanced Observations for Lower Atmospheric Research 3 Credit Hours
(Slashlisted with METR 4603) Prerequisite: Graduate standing and METR 5004 or concurrent enrollment, or permission of instructor. This course will examine the observation and operation principles behind a variety of research-grade instruments and the data they provide. Taught as a mix of lectures, instrument demonstrations, and data-focused projects, material presented focuses on modern, state-of-the-art instruments applied to current research problems emphasizing lower-atmospheric observations. Students use Python for processing, analysis, and visualization of real observed datasets. No student may earn credit for both 4603 and 5603. (F)

METR 5633 Hydrometeorology 3 Credit Hours
(Slashlisted with METR 4633) Prerequisite: graduate standing. Hydrometeorology is part of meteorology directly concerned with hydrologic problems, such as forecasting and observing heavy precipitation and floods and how such features impact flood control, hydroelectric power, irrigation and similar fields of engineering and water resource management. No student may earn credit for both 4633 and 5633. (Irreg.)

METR 5643 Quantitative Hydrometeorology 3 Credit Hours
(Crosslisted with CEES 5643) Prerequisite: Graduate standing or permission of instructor. Theory and concept of hydrometeorology and remote sensing, across atmospheric science and hydrology and across water science and engineering. An in-depth study of precipitation estimation from in-situ, radar, satellite, uncertainty modeling and decision making. Data analysis and computational methods for hydrometeorology. Special emphasis on probabilities/statistics and decision making. Basic level of scientific programming is helpful but not mandatory. (Irreg.)

METR 5663 Radar Engineering 3 Credit Hours
(Crosslisted with ECE 5663; Slashlisted with 4663) Prerequisite: grade of C or better in Electrical and Computer Engineering 3613, or permission. Introduction to radar system designs and applications with emphasis on weather radar. Radar system architecture and their functionalities and limitations of subsystems are discussed. Theories of radar detection and estimation in a noisy and cluttered environment; existing technologies and advanced techniques to improve radar performance. No student may earn credit in both 4663 and 5663. (F)

METR 5673 Weather Radar Theory and Practice 3 Credit Hours
(Crosslisted with ECE 5673) Prerequisite: grade of C or better in Mathematics 3113 and Physics 2524 or permission. This course provides an introduction to electromagnetic waves and propagation through the atmosphere, radar design trade-offs, antennas, transmitters, and coherent receivers. Analysis of radar signals as noise-corrupted stochastic processes, with emphasis on digital signal processing for Doppler spectrum and moment estimation. Implementation of processing algorithms using actual Doppler radar data. (F)

METR 5683 Weather Radar Applications 3 Credit Hours
(Crosslisted with ECE 5683) Prerequisite: Graduate standing in Meteorology or Engineering, or permission of instructor. Interpretation of meteorological structures using weather radar. Introduces scatter from hydrometeors and refractive index variations. Presentation of quantitative precipitation estimation methods based on the radar reflectivity factor, attenuation, and dual-polarization observations. Also includes the fundamental concepts of clear-air echoes and the estimation of winds under non-precipitation conditions. (Sp)

METR 5693 Environmental Sampling Methods 3 Credit Hours
(Slashlisted with METR 4693; Crosslisted with METR and PBIO 5693) Prerequisite: Graduate standing and permission of instructor. The course gives students from diverse STEM backgrounds experience and knowledge of environmental sampling techniques, analysis of data generated, and interpretation of results in a scientific field outside their primary area of study. The multi-disciplinary structure helps students develop an understanding of different sampling techniques based on assumptions and perspectives on the environment at different spatial scales. No student may earn credit for both 4693 and 5693.

METR 5713 Private Sector Meteorology 3 Credit Hours
Prerequisite: graduate standing in Meteorology. An overview of private sector meteorology in the United States. Designed to build background knowledge, foster the use of higher-order analytical skills, and further develop communication and presentation skills. The course includes lectures, directed readings, visiting local private sector companies, interviews with practicing meteorologists, and the development of a portfolio about a private sector meteorological company. Students gain experience in applying their meteorological knowledge to a practical problem as might be encountered in professional practice. No student may earn credit for both 4713 and 5713. (Irreg.)

METR 5733 Hydroclimatology 3 Credit Hours
(Crosslisted with CEES 5733) Prerequisite: Graduate standing or permission of instructor. Theory and concept of hydroclimatology across atmospheric science and hydrology. An in-depth study of the local to global climate of precipitation with specific foci on drought, pluvials, and how they vary in a changing climate system. Data analysis and computational methods for hydroclimatology. Basic level of scientific programming is helpful but not mandatory. (Su)

METR 5743 Forecast Evaluation and Decision Analysis 3 Credit Hours
Prerequisite: Graduate Standing or Permission of Instructor. The course is an overview of techniques and application for the evaluation of forecasts and classification problems in meteorology and other fields. It also includes basics in the analysis of decisions which relate to the value of forecasts, including models of decision making, and complexity of human decision processes. (Irreg.)

METR 5753 Forecast and Warning Communication 3 Credit Hours
(Slashlisted with METR 4753) Prerequisite: Graduate standing. This course explores the fundamental theories related to the communication of weather and climate information. We will explore effective risk communication, including characteristics of the forecast, the audience, and the message that most effectively convey the information to multiple audiences. Guest speakers will share their expertise so students see the range of jobs that exist in the weather/climate information sphere. No student may earn credit for both 4753 and 5753. (Irreg.)

METR 5803 Topics in Applied Meteorology 3 Credit Hours
Prerequisite: permission of instructor. May be repeated with change of subject matter; maximum credit 12 hours. Application of meteorological concepts and information to current environmental and meteorological problems on any scale.

METR 5960 Directed Readings 1-3 Credit Hours
1 to 3 hours. Prerequisite: graduate standing and permission of department. May be repeated; maximum credit twelve hours. Directed readings and/or literature reviews under the direction of a faculty member. (F, Sp, Su)

METR 5970 Special Topics/Seminar 1-3 Credit Hours
1 to 3 hours. Prerequisite: Graduate standing or permission of instructor. May be repeated; maximum credit nine hours. Special topics or seminar course for content not currently offered in regularly scheduled courses. May include library and/or laboratory research and field projects. (Irreg.)

METR 5980 Research for Master's Thesis 2-9 Credit Hours
Variable enrollment, two to nine hours; maximum credit applicable toward degree, four hours. (F, Sp, Su)

METR 5990 Independent Study 1-4 Credit Hours
1 to 4 hours. Prerequisite: graduate standing, permission of instructor. May be repeated with change of subject matter; maximum credit eight hours for master's degree students. Individual research problems in meteorology, climatology, hydrometeorology, and other areas of the atmospheric and earth sciences. (Irreg.)

METR 6103 Turbulence 3 Credit Hours
Prerequisite: Graduate standing and METR 5103 or METR 5113, or permission of instructor. Introduction to the evolution, structure, and effects of turbulent flow. Students will learn to use a variety of theoretical and practical tools of discovery and analysis. (Sp)

METR 6223 Convective Clouds and Storms 3 Credit Hours
Prerequisite: 5113 or equivalent. Anelastic and Boussinesq equations; Benard convection; plume models; parameterization of cloud microphysics; three-dimensional models; Doppler radar analysis; observations of severe thunderstorms and tornadoes. (Irreg.)

METR 6313 Advanced Data Assimilation Methods: Ensemble Kalman Filter Techniques and Applications 3 Credit Hours
Prerequisite: graduate standing or permission of instructor. Introduction to ensemble Kalman data assimilation techniques (EnKF). Students learn the most popular EnKF techniques through lectures and hands-on project assignments, and also develop skill in scientific thinking and synthesis, written and oral communication and programming throughout the course. (Irreg.)

METR 6413 Topics in Advanced Mesoscale Meteorology 3 Credit Hours
Prerequisite: 5113. Research topics in the areas of cyclogenesis, frontogenesis and mesoscale systems. Topics include "IPV thinking" and its application to cyclogenesis; trapped gravity currents and Kelvin waves; the dryline; rainbands in extratropical cyclones; air-sea instability; topographically induced eddies; generalization of the frontogenetical function.

METR 6613 Weather Radar Polarimetry 3 Credit Hours
(Crosslisted with ECE 6613) Prerequisite: graduate standing. Provides fundamentals and principles of weather radar polarimetry through understanding wave scattering and propagation in geophysical media subject to turbulent mixing and filled with hydrometeors and other objects. The relations between polarimetric radar observables and physical parameters will be established. The methods and algorithms for retrieving cloud and precipitation microphysics for weather quantification and forecast will be introduced. (F)

METR 6960 Directed Readings 1-3 Credit Hours
1 to 3 hours. Prerequisite: graduate standing or permission of instructor. May be repeated; maximum credit six hours. Directed readings and/or literature review under the direction of a faculty member. (Irreg.)

METR 6970 Seminar 1-3 Credit Hours
1 to 3 hours. Prerequisite: graduate standing and permission. May be repeated with change of subject matter; maximum credit four hours for master's degree, or 10 hours for doctor's degree. (F, Sp)

METR 6980 Research for Doctoral Dissertation 2-16 Credit Hours
2 to 16 hours. Prerequisite: Graduate standing and permission of instructor; may be repeated. Directed research culminating in the completion of the doctoral dissertation. (F, Sp, Su)

METR 6990 Special Problems 1-4 Credit Hours
1 to 4 hours. Prerequisite: graduate standing, permission of instructor. May be repeated with change of subject matter; maximum credit 12 hours for doctoral students. Individual research problems in meteorology and related areas conducted under faculty supervision. (F, Sp, Su)