# Meteorology Objectives and Outcomes

## Program Objectives

Program Objectives are statements that describe the expected accomplishments of graduates during the first few years after graduation

1. To produce graduates who possess quantitative, scientific reasoning skills that can be applied to atmospheric problems.
2. To produce graduates who have a general knowledge of a range of atmospheric phenomena and applications, and have expertise in one or more program subdisciplines or related interdisciplinary areas
3. To produce graduates who are equipped to contribute to solving problems in the atmospheric sciences and related disciplines, through service in business or as educators, researchers, and leaders in academia, government, the private sector, and civil society.

Program Outcomes
Statements that describe what students are expected to know and are able to do by the time of graduation. These relate to the skills, knowledge and behaviors that students acquire in their matriculation through the program.

1. Graduates can demonstrate skills for interpreting and applying atmospheric observations
2. Graduates can demonstrate knowledge of the atmosphere and its evolution
3. Graduates can demonstrate knowledge of the role of water in the atmosphere
4. Graduates can demonstrate facility with computer applications to atmospheric problems
5. Graduates can demonstrate skills for communicating their technical knowledge

## Objectives and Outcomes for Undergraduate Courses

A review of select syllabi demonstrating the relationship between program objectives and outcomes and course objectives and outcomes

### METEO 003: INTRODUCTORY METEOROLOGY

### **Objectives for Meteo 003**

1. Students can demonstrate knowledge of atmospheric composition and structure
2. Students can demonstrate knowledge of scientific methods relating to qualitative and quantitative analysis of atmospheric variables and can develop some basic analysis techniques to aid in understanding weather and climate
3. Students can demonstrate knowledge of a wide range of atmospheric phenomena and their roles in affecting weather and climate on local, regional, continental, and global scales

**Outcomes for Meteo 003**

1. Students can demonstrate knowledge of the typical vertical variation of the basic variables used to quantify the atmospheric state, including temperature, pressure, humidity, winds, and natural and anthropogenic particles
2. Students can demonstrate knowledge of the basic techniques used by meteorologists (and other scientists) to gather and interpret atmospheric data
3. Students can demonstrate knowledge of climate and climate change, together with the possible influences that humans have on diverse climate phenomena
4. Students can demonstrate knowledge of the forces that drive three-dimensional atmospheric motions
5. Students can demonstrate knowledge of clouds and their formation mechanisms, together with the precipitation types and other materials that precipitation cleanses from the air
6. Students can demonstrate knowledge of a variety of large-scale atmospheric phenomena, including the extratropical cyclone, the jet stream, and the general circulation
7. Students can demonstrate knowledge of a variety of mesoscale and small-scale atmospheric phenomena, including tropical storms, severe thunderstorms, and tornadoes

### METEO 003H: INTRODUCTORY METEOROLOGY HONORS

**Objectives for Meteo 003H**

1. Students can demonstrate knowledge of atmospheric composition and structure
2. Students can demonstrate knowledge of scientific methods relating to qualitative and quantitative analysis of atmospheric variables and can develop some basic analysis techniques to aid in understanding weather and climate
3. Students can demonstrate knowledge of a wide range of atmospheric phenomena and their roles in affecting weather and climate on local, regional, continental, and global scales

**Outcomes for Meteo 003H**

1. Students can demonstrate knowledge of the typical vertical variation of the basic variables used to quantify the atmospheric state, including temperature, pressure, humidity, winds, and natural and anthropogenic particles
2. Students can demonstrate knowledge of the basic techniques used by meteorologists (and other scientists) to gather and interpret atmospheric data
3. Students can demonstrate knowledge of climate and climate change, together with the possible influences that humans have on diverse climate phenomena
4. Students can demonstrate knowledge of the forces that drive three-dimensional atmospheric motions
5. Students can demonstrate knowledge of clouds and their formation mechanisms, together with the precipitation types and other materials that precipitation cleanses from the air
6. Students can demonstrate knowledge of a variety of large-scale atmospheric phenomena, including the extratropical cyclone, the jet stream, and the general circulation
7. Students can demonstrate knowledge of a variety of mesoscale and small-scale atmospheric phenomena, including tropical storms, severe thunderstorms, and tornadoes
8. Students can demonstrate knowledge of a variety of human-, turbulent-scale phenomena including transport and diffusion of natural and anthropogenic materials and contaminants
9. Students can demonstrate knowledge of some connections between weather and climate phenomena and the functionality and health of evolving cultures and society
10. Students can demonstrate knowledge of connections between weather and climate phenomena and challenges in national and global defense and security

### METEO 004: WEATHER AND RISK

**Objectives for Meteo 004**

1. Students can demonstrate knowledge of the distinction between pre-modern, folkloric, and “rule-of-thumb” forecasting techniques and those derived from general scientific principles
2. Students can demonstrate knowledge of the complementary roles of instrumentation, theory, and computation in creating and verifying weather forecasts
3. Students can demonstrate knowledge of the uses of weather forecasts for risk management in transportation, agriculture, military, energy, humanitarian, and other sectors

**Outcomes for Meteo 004**

1. Students can demonstrate knowledge of pre-scientific foretelling techniques and how these forecasts are verified
2. Students can demonstrate knowledge of scientific approaches to weather forecasting and how these forecasts are verified
3. Students can demonstrate knowledge of how the laws of physics guide the creation of usable weather forecasts
4. Students can demonstrate knowledge of modern risk management and how the increasing skill of meteorological forecasts has enabled increasingly sophisticated ways of managing risk
5. Students can demonstrate knowledge of how weather forecasts are used in decision settings

### METEO 101: UNDERSTANDING WEATHER FORECASTING

**Objectives for Meteo 101**

1. Students can demonstrate familiarity with key atmospheric variables and structures, the types of weather data available, the manner by which these data are collected, and some of the ways that these data are displayed, analyzed, and used (relate to program objectives 1 and 2)

2. Students can demonstrate the ability to produce forecasts of basic weather variables including high and low temperatures and precipitation (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 101**

1. Students can demonstrate the ability to analyze and interpret conventional maps of surface and upper-air data as well as soundings on a thermodynamic diagram (relate to program outcomes a, b, c, and e)
2. Students can demonstrate a fundamental knowledge of the basics by which atmospheric observations are taken, both in-situ and remotely (relate to program outcome a and e)
3. Students can demonstrate knowledge of synoptic-scale weather systems (relate to program outcomes b, c, and e)
4. Students can demonstrate knowledge of the fundamental forces that drive atmospheric motions both in the horizontal and vertical (relate to program outcomes a, b, c, and e)
5. Students can demonstrate knowledge of the basics underlying weather forecasting and numerical weather prediction (relate to program outcomes b, d, and e)

### METEO 201: INTRODUCTION TO WEATHER ANALYSIS

**Objectives for Meteo 201**

1. Students can demonstrate familiarity with key atmospheric variables and structures, the types of weather data available, the manner by which these data are collected, and some of the ways that these data are displayed, analyzed, and used (relate to program objectives 1 and 2)
2. Students can demonstrate familiarity with the options within the Bachelor of Science degree for Meteorology (relate to program objectives 2 and 3)

**Outcomes for Meteo 201**

1. Students can demonstrate the ability to plot, analyze, and interpret conventional maps of surface and upper-air data as well as soundings on a thermodynamic diagram (relate to program outcomes a, b, c)
2. Students can demonstrate a fundamental knowledge of the basics by which atmospheric observations are taken, both in-situ and remotely (relate to program outcome a)
3. Students can demonstrate knowledge of synoptic-scale and tropical weather systems as well as of the general circulation of the atmosphere (relate to program outcomes b and c)
4. Students can demonstrate knowledge of the fundamental forces that drive atmospheric motions both in the horizontal and vertical (relate to program outcomes a, b, and c)
5. Students can demonstrate knowledge of the basics underlying numerical weather prediction (relate to program outcomes b and d)

### METEO 241: FUNDAMENTALS OF TROPICAL FORECASTING

**Objectives for Meteo 241**

1. Students can demonstrate knowledge of the climatology of the tropical regions
2. Students can demonstrate knowledge of the mechanisms for the formation and evolution of tropical storms
3. Students can demonstrate knowledge of tropical climatic signals (monsoons and El Nino/La Nina) and the impact on global and regional weather patterns

**Outcomes for Meteo 241**

1. Students can demonstrate knowledge of the methods used for making in-situ and remotely sensed observations of tropical phenomena
2. Students can demonstrate knowledge of the structure of tropical storms and the atmospheric conditions conducive for their development and movement
3. Students can demonstrate knowledge of the techniques used to forecast the onset and evolution of tropical storms
4. Students can demonstrate knowledge of the global general circulation and can apply related principles to tropical weather forecasting
5. Students can apply knowledge of the tropical responses from monsoons and El Nino/La Nina to seasonal forecasting in the tropics and middle latitudes
6. Students can demonstrate knowledge of the products on Penn State’s Tropical e-Wall (http://www.meteo.psu.edu/~gadomski/ewalltropmain.html ) and can apply those products to tropical forecasting
7. Students can demonstrate the ability to comprehend and apply analyses and forecasts routinely issued by the National Hurricane Center and the Joint Typhoon Warning Center

### METEO 300: FUNDAMENTALS OF ATMOSPHERIC SCIENCE

**Objectives for Meteo 300**

1. Students can demonstrate familiarity with the application of calculus to provide a quantitative description of atmospheric phenomena (relate to program objectives 1 and 3)
2. Students can demonstrate familiarity with the application of basic physical laws to provide a detailed explanation for the development and evolution of atmospheric phenomena at a variety of spatial and temporal scales (relate to program objectives 2)

**Outcomes for Meteo 300**

1. Students can demonstrate a broad fundamental knowledge of atmospheric dynamics, atmospheric thermodynamics, atmospheric chemistry, and physical meteorology as preparation for taking other required and elective meteorology courses (relate to program outcome b)
2. Students can demonstrate the ability to solve basic analytical problems in the fundamental areas of the atmospheric sciences (relate to program outcome a, b, c, and d)

### METEO 361: FUNDAMENTALS OF MESOSCALE WEATHER FORECASTING

**Objectives for Meteo 361**

1. Students can demonstrate familiarity with the dynamic and physical principles underlying the structure, development, and evolution of mesoscale weather systems
2. Students can demonstrate the ability to produce short-term forecasts of a variety of weather variables for a variety of mesoscale atmospheric systems
3. Students can demonstrate knowledge of the role that synoptic-scale systems play in mesoscale weather patterns and also can develop the ability to apply principles of synoptic-scale weather forecasting to mesoscale weather forecasting

**Outcomes for Meteo 361**

1. Students can demonstrate knowledge of how the vertical structure of the atmosphere controls the onset and evolution of convective phenomena
2. Students can demonstrate knowledge of how various indices and maps derived from atmospheric soundings can reveal the potential for severe convection to occur in the atmosphere
3. Students can demonstrate knowledge of the role of Convective Available Potential Energy and wind shear in determining the evolution of mesoscale phenomena
4. Students can demonstrate knowledge of the use of atmospheric radar returns to diagnose the structure of precipitating systems and the potential for such severe weather as flash flooding, hail formation, tornadoes, lightning, and damaging straight-line winds
5. Students can demonstrate the ability to create and disseminate a useful real-time mesoscale weather prediction under time constraints, based on current observations and numerical forecasts of the atmosphere
6. Students can demonstrate the ability to apply analyses and forecasts routinely issued by the Storm Prediction Center in Norman, Oklahoma

### METEO 410: ADVANCED TOPICS IN WEATHER FORECASTING

**Objectives for Meteo 410**

1. Students can demonstrate the ability to produce real-time forecasts of a variety of weather variables for atmospheric systems that span the mesoscale to the planetary scale
2. Students can demonstrate the ability to use the output from numerical weather prediction models to guide the creation of short-term weather forecasts

**Outcomes for Meteo 410**

1. Students can demonstrate knowledge of the Norwegian cyclone model and its use as a conceptual framework for the creation of a weather forecast
2. Students can demonstrate knowledge of the roles of both the upper-level flow (e.g., the jet stream) and the thermodynamic structure in determining the expected evolution of the atmosphere at various locations
3. Students can demonstrate knowledge of orographic influences on precipitation
4. Students can demonstrate the ability to use dynamic, statistical, and ensemble numerical forecasts of the atmosphere to diagnose quantitatively the likely atmospheric conditions at a specific location
5. Students can demonstrate the ability to create and disseminate in a timely fashion a useful weather forecast based on current observations and numerical forecasts of the atmosphere

### METEO 411: SYNOPTIC METEOROLOGY LABORATORY

**Objectives for Meteo 411**

1. Students can demonstrate skills for the analysis of synoptic-scale surface and upper-air observations of the atmosphere (relate to program objectives 1 and 3)
2. Students can demonstrate familiarity with the principles underlying the structure, development, and evolution of synoptic-scale weather systems (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 411**

1. Students can demonstrate knowledge of the Norwegian cyclone model and its use as a conceptual framework for the analysis of atmospheric structure at the synoptic scale (relate to program outcomes a and b)
2. Students can demonstrate knowledge of the methods for determining vertical motion in the atmosphere qualitatively (relate to program outcomes a, b, and d)
3. Students can demonstrate knowledge of the role of the upper-level flow (e.g., the jet stream) in the development of extratropical cyclones (relate to program outcomes a, b and d)
4. Students can demonstrate the ability to apply quasi-geostrophic theory to the development and evolution of fronts and extratropical cyclones (relate to program outcomes a, b and d)

### METEO 413: MAP ANALYSIS

**Objectives for Meteo 413**

1. Students can demonstrate familiarity with the Norwegian cyclone model and how well it describes the surface and upper-air observations (relate to program objectives 2 and 3)
2. Students can demonstrate skills for the analysis of synoptic-scale and mesoscale surface and upper-air observations of the atmosphere (relate to program objectives 1 and 3)

**Outcomes for Meteo 413**

1. Students can demonstrate the ability to analyze and interpret maps of surface and upper-air data (relate to program outcomes a, b, c, and e)
2. Students can demonstrate knowledge of the structure and evolution of synoptic-scale and mesoscale weather systems (relate to program outcomes b and c)
3. Students can demonstrate knowledge of land- and ocean-surface influences on synoptic-scale and mesoscale weather systems (relate to program outcomes b and c)

### METEO 414: MESOSCALE METEOROLOGY

**Objectives for Meteo 414**

1. Students can demonstrate skill in the analysis of mesoscale phenomena using surface and upper-air observations of the atmosphere (relate to program objectives 1, 2, and 3)
2. Students can demonstrate familiarity with the dynamic and physical principles underlying the structure, development, and evolution of mesoscale weather systems (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 414**

1. Students can demonstrate knowledge of how the vertical structure of the atmosphere controls the behavior of convective phenomena and gravity waves (relate to program outcomes a, b, and c)
2. Students can demonstrate knowledge of how various indices and maps derived from atmospheric soundings can reveal the potential for severe convection to occur in the atmosphere (relate to program outcomes a, b, and c)
3. Students can demonstrate knowledge of the role of vorticity in determining the evolution of mesoscale phenomena (relate to program outcomes a and b)
4. Students can demonstrate knowledge of the use of atmospheric radar returns to diagnose the structure of precipitating systems and the occurrence of such severe weather as flash flooding, hail, tornadoes, and lake-effect snowstorms (relate to program outcomes a, b, and c)
5. Students can demonstrate knowledge of the effects of topography on the structure of mesoscale systems (relate to program outcomes a and b)

### METEO 415: FORECASTING PRACTICUM

**Objectives for Meteo 415**

1. Students can demonstrate the ability to produce forecasts of a variety of weather variables for atmospheric systems that occur throughout the year (relate to program objectives 1, 2, and 3)
2. Students can demonstrate the ability to use numerical weather prediction models to guide the creation of weather forecasts (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 415**

1. Students can demonstrate knowledge of the Norwegian cyclone model and other conceptual models to be used as a framework for the creation of a weather forecast (relate to program outcomes a, b, and c)
2. Students can demonstrate knowledge of the roles of both the upper-level flow (e.g., the jet stream) and the thermodynamic structure in determining the expected evolution of the atmosphere at various locations (relate to program outcomes a, b, and c)
3. Students can demonstrate knowledge of how orography and large bodies of water affect various aspects of local weather such as cloud and precipitation patterns (relate to program outcomes a, b, and c)
4. Students can demonstrate the ability to use dynamic, statistical, and ensemble numerical forecasts of the atmosphere to diagnose quantitatively the likely atmospheric conditions at a specific location (relate to program outcomes a, b, and c)
5. Students can demonstrate the ability to create and disseminate a useful weather forecast based on current observations and numerical forecasts of the atmosphere (relate to program outcomes a, b, c, d, and e)

### METEO 416: ADVANCED FORECASTING

**Objectives for Meteo 416**

1. Students can demonstrate the ability to produce short-term forecasts of a variety of weather variables for atmospheric systems that occur throughout the year (relate to program objectives 1, 2, and 3)
2. Students can demonstrate the ability to use real-time observations and numerical weather predictions to guide the creation of timely short-term probabilistic and threat weather forecasts at a variety of locations (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 416**

1. Students can demonstrate the ability to lead discussions and verifications of mesoscale forecasts using satellite, radar, and surface observations (relate to program outcomes a, b, c, d, and e)
2. Students can demonstrate a knowledge of a variety of forecast verification tools and measures of forecast skill (relate to program outcomes a and d)
3. Students can demonstrate the ability to design a conceptual forecast model of a cold or a warm season phenomenon and to present it to the class (relate to program outcomes b, c, and e)
4. Students can demonstrate the ability to create and disseminate a useful real-time mesoscale weather prediction under time constraints, based on current observations and numerical forecasts of the atmosphere (relate to program outcomes a, b, c, d, and e)
5. Students can demonstrate discernment among a wide variety of data sources and evaluate their applicability to the forecast problem (relate to program outcomes a and b)

### METEO 418W: TOPICS IN MESOSCALE METEOROLOGY

**Objectives for Meteo 418W**

1. Students can demonstrate familiarity with the dynamic and physical principles underlying the structure, development, and evolution of a variety of mesoscale weather systems (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 418W**

1. Students can demonstrate knowledge of the effects of topography on the structure of mesoscale systems (relate to program outcomes a and b)
2. Students can demonstrate knowledge of how the vertical structure of the atmosphere controls the onset and evolution of a variety of convective phenomena (relate to program outcomes a, b, and c)
3. Students can demonstrate knowledge of the use of a variety of atmospheric sampling tools to diagnose the mesoscale structure of precipitating systems and the potential for the occurrence of potentially hazardous weather such as flash floods, hail, microburst winds, tornadoes, and lake-effect snowstorms (relate to program outcomes a, b, c, and d)
4. Students can demonstrate the ability to acquire extensive atmospheric knowledge via independent study using computer-based modules (relate to program outcomes b, c, and d)
5. Students can demonstrate the ability to summarize their knowledge of mesoscale phenomena through technical written reports of individualized case studies (relate to program outcomes a, b, c, and e)

### METEO 421: ATMOSPHERIC DYNAMICS

**Objectives for Meteo 421**

1. Students can demonstrate skills in applying calculus to the quantitative description of atmospheric phenomena (relate to program objectives 1 and 3)
2. Students can demonstrate familiarity with how basic physical laws are applied to provide knowledge of the development and evolution of weather phenomena primarily at the planetary and synoptic scales (relate to program objectives 2 and 3)

**Outcomes for Meteo 421**

1. Students can demonstrate the ability to apply the equations of motion to the quantitative description of a variety of atmospheric motions including the general circulation (relate to program outcomes b and d)
2. Students can demonstrate knowledge of balanced and unbalanced flows that form the basis for the depiction of atmospheric motions (relate to program outcome b)
3. Students can demonstrate knowledge of the rotational aspects of large-scale atmospheric motions as described by vorticity and circulation (relate to program outcome b and d)
4. Students can demonstrate the ability to apply wave dynamics and stability concepts to atmospheric problems (relate to program outcome b and d)

### METEO 422: ADVANCED ATMOSPHERIC DYNAMICS

**Objectives for Meteo 422**

1. Students can demonstrate skills in applying calculus and differential equations to the quantitative description of atmospheric phenomena (relate to program objectives 1, 2, and 3)
2. Students can demonstrate familiarity with how basic physical laws are applied to provide knowledge of the development and evolution of weather phenomena at a range of temporal and spatial scales (relate to program objectives 2 and 3)

**Outcomes for Meteo 422**

1. Students can demonstrate the ability to apply the equations of motion to the quantitative description of a variety of atmospheric motions including the general circulation (relate to program outcomes b and d)
2. Students can demonstrate knowledge of how wave motion and the instability of equilibrium conditions can provide the basis for the description of the development of several different atmospheric phenomena (relate to program outcome b)
3. Students can demonstrate knowledge of the principles underlying the creation and application of numerical models of the atmosphere (relate to program outcome b and d)

### METEO 431: ATMOSPHERIC THERMODYNAMICS

**Objectives for Meteo 431**

1. Students can demonstrate an ability to apply thermodynamic principles quantitatively to atmospheric problems (relate to program objectives 1 and 3)
2. Students can demonstrate the use of thermodynamics equations in determining the thermal structure of basic atmospheric phenomena (relate to program objectives 2)

**Outcomes for Meteo 431**

1. Students can demonstrate knowledge of how thermal energy and the first law of thermodynamics are applied to describe atmospheric thermal properties and structure (relate to program outcomes b)
2. Students can demonstrate knowledge of how entropy and the second law of thermodynamics are applied to basic thermal problems (relate to program outcome b)
3. Students can demonstrate knowledge of the process of phase change in atmospheric phenomena (relate to program outcomes b and c)
4. Students can demonstrate an ability to analyze atmospheric soundings using a thermodynamic diagram (relate to program outcomes a, b, c, and d)

### METEO 434: RADAR METEOROLOGY

**Objectives for Meteo 434**

1. Students can demonstrate skills for the analysis and interpretation of radar imagery of the atmosphere (relate to program objectives 1, 2, and 3)
2. Students can demonstrate familiarity with the electromagnetic principles underlying the sampling of the atmosphere using radars (relate to program objective 1)

**Outcomes for Meteo 434**

1. Students can demonstrate the ability to describe in class a variety of atmospheric phenomena depicted on radar imagery (relate to program outcomes a, b, c, and e).
2. Students can demonstrate the ability to quantify the reflectivity and radial velocity field as measured by radar given a description of a weather phenomenon (relate to program outcomes a and d).
3. Students can demonstrate the ability to relate radar reflectivity to rainfall rate, and discuss factors that contribute to the uncertainty in the rainfall rate estimation (relate to program outcomes a, b and c).
4. Students can demonstrate the ability to discuss basic principles of multi-parameter radar measurements (relate to program outcomes a, c, and e).

### METEO 436: RADIATION AND CLIMATE

**Objectives for Meteo 436**

1. Students can demonstrate how radiative processes are related to atmospheric structure and phenomena (relate to program objectives 1 and 2)
2. Students can demonstrate the ability to apply atmospheric radiative principles quantitatively to atmospheric problems (relate to program objectives 1 and 3)

**Outcomes for Meteo 436**

1. Students can demonstrate knowledge of absorption, emission, and scattering properties along with the equations for radiance, irradiance, and solid angle (relate to program outcomes b and c)
2. Students can demonstrate a basic grasp of the integro-differential form of the radiative transfer equation by providing a physical interpretation (relate to program outcome b)
3. Students can solve the integro-differential form of the radiative transfer equation for simplified atmospheres such as attenuation-only with no scattering (relate to program outcome b and d)
4. Students can demonstrate the use of simplified solutions of the integro-differential form of the radiative transfer equation to basic remote sensing of the atmosphere (relate to program outcomes a and d)
5. Students can show the link of atmospheric irradiance to atmospheric heating and cooling (relate to program outcome b)

### METEO 437: ATMOSPHERIC CHEMISTRY AND CLOUD PHYSICS

**Objectives for Meteo 437**

1. Students can demonstrate familiarity with microphysical principles and how they determine the structures of the atmosphere and clouds (relate to program objectives 1 and 2)
2. Students can demonstrate the ability to apply principles of cloud microphysics and atmospheric chemistry to the solution of atmospheric problems (relate to program objectives 1 and 3)

**Outcomes for Meteo 437**

1. Students can demonstrate knowledge of cloud properties (relate to program outcomes a, b, and c)
2. Students can demonstrate knowledge of the thermodynamic drivers of cloud development and evolution (relate to program outcomes b, c, and d)
3. Students can demonstrate knowledge of basic atmospheric chemistry and its role in atmospheric phenomena (relate to program outcome b)

### METEO 440W: PRINCIPLES OF ATMOSPHERIC MEASUREMENTS

**Objectives for Meteo 440W**

1. Students can demonstrate knowledge of the principles underlying common physical and chemical measurements of the atmosphere (relate to program objectives 1 and 3)
2. Students can demonstrate familiarity with how atmospheric observations are analyzed statistically (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 440W**

1. Students can demonstrate the ability to take and analyze atmospheric observations (relate to program outcomes a and d)
2. Students can demonstrate knowledge of how precision, accuracy, and statistical analysis techniques are used to provide a description of the state of the atmosphere (relate to program outcomes a and d)
3. Students can demonstrate the ability to write scientific reports summarizing atmospheric observations and the analyses of them (relate to program outcomes a and e)

### METEO 448: STORMWATER HYDROLOGY

**Objectives for Meteo 448**

1. Students can demonstrate familiarity with the effects that local land use changes and urbanization have on precipitation runoff, stream flow, and stream chemistry (relate to program objectives 1 and 3)
2. Students can demonstrate familiarity with models that are used to assess the precipitation runoff potential as a consequence of new construction (relate to program objectives 1 and 3)

**Outcomes for Meteo 448**

1. Students can demonstrate the ability to interpret a hydrograph and its relationship to changes in surface precipitation runoff and stream chemistry caused by rainstorms (relate to program outcomes a and c)
2. Students can demonstrate the ability to calculate precipitation runoff from housing and road construction projects (relate to program outcomes a and c)
3. Students can demonstrate knowledge of how to build discharge conduits (relate to program outcome c)
4. Students can demonstrate the ability to assess quantitatively the effects of precipitation runoff on stream chemistry and water quality (relate to program outcomes a and c)
5. Students can demonstrate the ability to acquire and summarize measurements of stream chemistry and water quality obtained during field trips to local streams (relate to program outcomes a, c, and e)

### METEO 451: INTRODUCTION TO PHYSICAL OCEANOGRAPHY

**Objectives for Meteo 451**

1. Students can demonstrate a theoretical knowledge of the causes of large-scale basin-wide circulations in the ocean (relate to program objectives 1, 2, and 3)
2. Students can demonstrate skills in applying calculus and the basic laws of physics to the quantitative description of oceanic circulations (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 451**

1. Students can demonstrate knowledge of the dynamics of a variety of oceanic circulations including the Gulf Stream, ocean gyres, and the thermohaline circulation (relate to program outcomes b and d)
2. Students can demonstrate knowledge of the Ekman theory of a wind-driven ocean that explains upwelling (relate to program outcome b)
3. Students can demonstrate knowledge of equatorial ocean dynamics including the El Nino/Southern Oscillation (relate to program outcome b)
4. Students can manipulate and model oceanographic data in a laboratory setting to help develop improved knowledge of oceanic circulations (relate to program outcomes a, d, and e)

### METEO **452: TROPICAL METEOROLOGY**

**Objectives for Meteo 452**

1. Students can demonstrate a theoretical knowledge underlying the formation and evolution of tropical weather systems (relate to program objectives 1, 2, and 3)
2. Students can demonstrate detailed knowledge of the climatology of the tropical regions (relate to program objectives 2 and 3)

**Outcomes for Meteo 452**

1. Students can demonstrate knowledge of the structure of tropical storms and the atmospheric conditions conducive for their development and movement (relate to program outcomes b and c)
2. Students can demonstrate knowledge of the techniques used to forecast the development and evolution of tropical storms (relate to program outcomes a, b and c)
3. Students can demonstrate knowledge of the role that the tropics plays in the global general circulation (relate to program outcomes b and c)
4. Students can demonstrate knowledge of tropical waves and their relationship to organized convection in the tropics and to tropical cyclogenesis (relate to program outcomes b and c)
5. Students can demonstrate knowledge of major sources of tropical variability including the El Nino/Southern Oscillation and the Madden-Julian Oscillation (relate to program outcomes b and c)

### METEO 454: MICROMETEOROLOGY

**Objectives for Meteo 454**

1. Students can demonstrate knowledge of the principles determining the structure of microscale phenomena within the planetary boundary layer (relate to program objectives 1 and 2)
2. Students can demonstrate an introductory knowledge of the role of turbulence in the atmosphere ((relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 454**

1. Students can demonstrate knowledge of the energy budget near the earth’s surface (relate to program outcomes b and c)
2. Students can demonstrate knowledge of the role that radiative transfer plays in explaining differences between the structure of the daytime and nighttime planetary boundary layers (relate to program outcomes b and c)
3. Students can demonstrate an ability to describe qualitatively and quantitatively the vertical profiles of air temperature, humidity, wind, and passive scalars in the planetary boundary layer (relate to program outcomes a, b, c, and d)
4. Students can demonstrate knowledge of the processes by which turbulence is created and acts to affect the atmosphere (relate to program outcomes b and c)
5. Students can demonstrate preliminary knowledge of the role of turbulence in the dispersion of pollutants in the atmosphere (relate to program outcome b)

### METEO 455: ATMOSPHERIC DISPERSION

**Objectives for Meteo 455**

1. Students can demonstrate detailed knowledge of the structure and evolution of the planetary boundary layer and its effects on dispersion of pollutants in the atmosphere (relate to program objectives 1, 2, and 3)
2. Students can demonstrate a detailed knowledge of the principles underlying dispersion modeling (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 455**

1. Students can demonstrate knowledge of atmospheric turbulence and its role in the dispersion of constituents (relate to program outcome b)
2. Students can demonstrate knowledge of buoyancy, stability, and their influence on dispersion in the lower atmosphere (relate to program outcomes b and c)
3. Students can demonstrate knowledge of the contrast between instantaneous and average properties of turbulent flow (relate to program outcome b)
4. Students can demonstrate knowledge of the key concepts underlying the modeling of turbulent dispersion of an effluent (relate to program outcomes b and d)
5. Students can demonstrate facility with using and interpreting the results given by models of atmospheric dispersion (relate to program outcomes a, b and d)

### METEO 460: WEATHER RISK AND FINANCIAL MARKETS

**Objectives for Meteo 460**

1. Students can demonstrate knowledge of the role that weather plays as a source of financial and operational risk for businesses, markets, and other institutions (relate to program objectives 1, 2, and 3)
2. Students can demonstrate knowledge of weather risk management—the insurance products, financial derivatives, and decision tools that institutions can use to reduce their weather-related risks (relate to program objectives 1 and 3)

**Outcomes for Meteo 460**

1. Students can demonstrate knowledge of the financial tools for managing weather- and climate-related risks (relate to program outcomes a and b)
2. Students can demonstrate knowledge of probabilistic weather forecasting and its applications to assessing weather risk (relate to program outcomes a, b, and d)
3. Students can demonstrate knowledge of pricing models and contracts used to manage weather risk (relate to program outcomes a and b)
4. Students can demonstrate facility with designing weather risk management solutions (relate to program outcomes a, b, and e)

### METEO 465: MIDDLE ATMOSPHERE METEOROLOGY

**Objectives for Meteo 465**

1. Students can demonstrate knowledge of the physical, chemical, and dynamical processes at work in the middle atmosphere that comprises the stratosphere, mesosphere, and ionosphere (relate to program objectives 1, 2, and 3)
2. Students can demonstrate knowledge of the roles that middle atmospheric structure and dynamics play in modulating tropospheric responses (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 465**

1. Students can demonstrate knowledge of the composition and structure of the middle atmosphere (relate to program outcomes b and c)
2. Students can demonstrate knowledge of the photochemical processes in the middle atmosphere (relate to program outcomes b and c)
3. Students can demonstrate knowledge of the middle atmospheric waves and their interactions with tropospheric dynamics (relate to program outcome b)
4. Students can demonstrate knowledge of the ionic composition and structure of the middle atmosphere (relate to program outcome b)
5. Students can demonstrate knowledge of middle atmospheric phenomena of current interest such as ozone depletion and the interactions of middle atmospheric chemistry with climate (relate to program outcomes a, b, and c)

### METEO 466: PLANETARY ATMOSPHERES

**Objectives for Meteo 466**

1. Students can demonstrate knowledge of the origin and composition of the atmospheres of planets in the solar system (relate to program objectives 1, 2, and 3)
2. Students can demonstrate knowledge of the long-term evolution of earth’s climate (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 466**

1. Students can demonstrate knowledge of the formation and evolution of the planets in our solar system (relate to program outcomes b and c)
2. Students can demonstrate knowledge of the evolution of the atmospheres in both terrestrial planets and giant planets (relate to program outcomes b and c)
3. Students can demonstrate knowledge of observations obtained from space missions to the planets (relate to program outcomes b and c)
4. Students can demonstrate knowledge of the relationships between the evolution of the climates on planets and the possible future evolution of Earth’s climate (relate to program outcomes b and c)
5. Students can demonstrate knowledge of planets in solar systems beyond our own (relate to program outcomes b and c)
6. Students can demonstrate the ability to write an accurate technical report on a planetary atmospheres topic (relate to program outcomes b and e)

### METEO **470: CLIMATE DYNAMICS**

**Objectives for Meteo 470**

1. Students can demonstrate knowledge of the dynamics and thermodynamics governing the ocean and atmosphere on spatial and temporal scales appropriate for climate systems (relate to program objectives 1 and 2)
2. Students can demonstrate knowledge of the basic mechanisms of climate variability that are related to the coupling of the ocean and the atmosphere (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 470**

1. Students can demonstrate knowledge of radiation and its role in determining atmospheric thermal structure. (relate to program outcomes b and c)
2. Students can demonstrate knowledge of the atmospheric general circulation and energy budget as well as their roles in determining the climate state and its variability, with possible applications to ocean-atmospheric responses such as El Nino/Southern Oscillation and/or ocean circulation dynamics (relate to program outcomes a and c)
3. Students can demonstrate knowledge of the appropriate temporal and spatial averaging of the governing equations relevant to the description of climate and its variability (relate to program outcomes a and b)
4. Students can demonstrate knowledge of the state of the ocean, wind-driven oceanic circulations, thermohaline circulations, and coupled ocean-atmosphere processes, and their roles in determining the climate state and its variability (relate to program outcomes a and c)
5. Students can demonstrate knowledge of internal and forced climate variability (relate to program outcomes b and c)
6. Students can demonstrate knowledge of past climates (relate to program outcomes b and c)
7. Students can demonstrate knowledge of the processes responsible for climate change and how global climate models are used to assess it (relate to program outcomes b, c, and d)

### METEO 471W: OBSERVING METEOROLOGICAL PHENOMENA

**Objectives for Meteo 471W**

1. Students can demonstrate knowledge of a variety of observable phenomena occurring in the earth’s atmosphere (relate to program objectives 1 and 2)

**Outcomes for Meteo 471W**

1. Students can demonstrate the ability to explain correctly the underlying causes of a variety of phenomena that are visible from the earth’s surface (relate to program outcomes a, b, and c)
2. Students can demonstrate the ability to write scientifically accurate technical reports summarizing observations and analyses of a variety of atmospheric phenomena (relate to program outcomes a, b, c, and e)
3. Students can demonstrate the ability to present clear oral reports describing the phenomena that they have studied (relate to program outcomes a, b, c, and e)

### METEO 473: APPLICATION OF COMPUTERS TO METEOROLOGY

**Objectives for Meteo 473**

1. Students can demonstrate skills in using computers to develop and apply numerical algorithms for the solution of atmospheric problems (relate to program objectives 1 and 3)
2. Students can demonstrate the ability to use new programming knowledge as needed for solving problems (relate to program objectives 1 and 3)
3. Students can demonstrate the ability to work in a team to produce a final product (relate to program objective 3)

**Outcomes for Meteo 473**

1. Students can demonstrate a working knowledge of relevant computer languages and how they may be applied to the analysis and display of atmospheric data (relate to program outcomes a and d)
2. Students can demonstrate the ability to locate and develop programming methods for application to atmospheric problems (relate to program outcome d)
3. Students can demonstrate the ability to work in teams and to meet deadlines (relate to program outcome d)
4. Students can demonstrate the ability to document their methodology within a computer code (relate to program outcomes d and e)
5. Students can demonstrate the ability to use the Worldwide Web for dissemination of results (relate to program outcome e)

### METEO 474: COMPUTER METHODS IN METEOROLOGICAL ANALYSIS AND FORECASTING

**Objectives for Meteo 474**

1. Students can demonstrate skills in using computer methods for statistical analysis of atmospheric problems and for evaluating weather forecasts (relate to program objectives 1, 2, and 3)
2. Students can demonstrate skills for applying computer methods to the development of accurate and robust weather forecast systems (relate to program objectives 1 and 3)

**Outcomes for Meteo 474**

1. Students can demonstrate the ability to conduct an objective statistical verification of weather forecasts (relate to program outcomes a and d)
2. Students can demonstrate knowledge of current methods for statistical prediction of atmospheric phenomena (relate to program outcomes a and d)
3. Students can demonstrate the ability select appropriate statistical methods based on the type of problem and its degree of nonlinearity (relate to program outcomes a and d)
4. Students can demonstrate knowledge of the economic value of forecasts (relate to program outcomes a and d)

### METEO 477: FUNDAMENTALS OF REMOTE SENSING SYSTEMS

**Objectives for Meteo 477**

1. Students can demonstrate knowledge of techniques for sensing the atmosphere remotely using radio frequency, optical, and acoustic methods (relate to program objectives 1 and 2)
2. Students can demonstrate the ability to interpret physically remotely sensed active and passive electromagnetic and acoustic signals transmitted in the atmosphere (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 477**

1. Students can demonstrate knowledge of scattering and radiative transfer as they relate to remote sensing techniques (relate to program outcomes b and c)
2. Students can demonstrate knowledge of a variety of passive optical and radio-frequency systems used to diagnose atmospheric properties (relate to program outcomes a, b, and c)
3. Students can demonstrate knowledge of a variety of active optical and radio-frequency systems used to diagnose atmospheric properties (relate to program outcomes a, b, and c)
4. Students can demonstrate knowledge of additional methods for remotely sensing atmospheric conditions (relate to program outcomes a, b, and c)
5. Students can demonstrate knowledge of errors that can occur in the observations produced by remote sensing systems (relate to program outcome a)

### METEO 480M/480W: UNDERGRADUATE RESEARCH

**Objectives for Meteo 480M/480W**

1. Students can demonstrate the ability to complete and write a technical report on a research project overseen by a faculty member or other scientist (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 480M/480W**

1. Students can demonstrate knowledge of effective scientific writing principles, including proper organization of the material and use of good grammar (relate to program outcomes b and e)
2. Students can demonstrate knowledge of good practices in reviewing and editing atmospheric science manuscripts (relate to program outcomes b and e)
3. Students can demonstrate knowledge of issues underlying proper scientific ethical behavior, such as plagiarism and authorship (relate to program outcome e)

### METEO 481: WEATHER COMMUNICATIONS I

**Objectives for Meteo 481**

1. Students can demonstrate knowledge of effective approaches for communicating accurate information about the weather, both via speaking and writing (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 481**

1. Students can demonstrate knowledge of the basic principles for creating weather forecasts (relate to program outcomes a, b, and c)
2. Students can demonstrate the ability to present a weather forecast in both radio and television broadcasting formats (relate to program outcomes a, b, c, and e)
3. Students can demonstrate the ability to write for a general audience a scientifically accurate summary of an atmospheric topic (relate to program outcomes b and e)
4. Students can demonstrate knowledge of the role that climatology plays in forensics (relate to program outcomes a, b, c and e)
5. Students can demonstrate knowledge of the relationship between the atmosphere and the environment (relate to program outcomes c and e)

### METEO 482: WEATHER COMMUNICATIONS II

**Objectives for Meteo 482**

1. Students can demonstrate knowledge of effective approaches for communicating accurate information about the atmosphere, both via speaking and writing (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 482**

1. Students can demonstrate knowledge of the basic principles for creating effective weather discussions both orally and in writing (relate to program outcomes a, b, c, and e)

2. Students can demonstrate the ability to present a weather forecast using radio, television, and newspaper formats (relate to program outcomes a, b, c, and e)

3. Students can demonstrate the ability to present an interview of an expert on an atmospheric topic via radio, television, and newspaper formats (relate to program outcomes a, b, c, and e)

4. Students can demonstrate the ability to create a tool using information about the atmosphere that industry could use in a profit-making enterprise (relate to program outcomes a, b, c, and e)

5. Students can demonstrate knowledge of watersheds and the built environment as they relate to atmospheric processes (relate to program outcomes b, c and e)

### METEO 483: WEATHER COMMUNICATIONS III

**Objectives for Meteo 483**

1. Students can demonstrate knowledge and creative approaches for communicating new and accurate information about the atmosphere, both via speaking and writing through the media (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 483**

1. Students can demonstrate a mastery of communication technology as a vehicle to more effectively convey atmospheric scientific information (relate to program outcomes a, b, c, and e)
2. Students can demonstrate improving skill in connecting weather information to a specific user group (relate to program outcomes a, b, c, and e)
3. Students can demonstrate the ability to create explanatory graphics on an atmospheric topic via radio, television, and newspaper formats (relate to program outcomes a, b, c, and e)
4. Students can demonstrate a knowledge of basic research tools and methods used in the atmospheric sciences (relate to program outcomes b, d and e)

### METEO 484: WEATHER COMMUNICATIONS APPRENTICESHIP

**Objectives for Meteo 484**

1. Students can demonstrate knowledge in science communication based on a direct mentorship with experts in the field (relate to program objectives 1 and 3)

**Outcomes for Meteo 484**

1. Students can demonstrate skill in digesting and representing technical information in an effective manner (relate to program outcomes b and e)

### METEO 485: NATIONAL WEATHER SERVICE OPERATIONS

**Objectives for Meteo 485**

1. Students can demonstrate knowledge of the services provided by the National Weather Service (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 485**

1. Students can demonstrate knowledge of the daily routine activities of personnel in a National Weather Service office (relate to program outcomes a, b, c, d, and e)
2. Students can demonstrate knowledge of the activities of personnel in a National Weather Service office during severe weather situations (relate to program outcomes a, b, c, d, and e)

### METEO 486: PENNSYLVANIA CLIMATE STUDIES

**Objectives for Meteo 486**

1. Students can demonstrate knowledge of the services provided by the Pennsylvania State Climate Office (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 486**

1. Students can demonstrate the ability to complete and summarize the results of a project on a topic related to Pennsylvania climate (relate to program outcomes a, b, c, d, and e)
2. Students can demonstrate a variety of skills in data retrieval and quality assurance as well as statistical techniques for displaying large data sets (relate to program outcomes a, d and e)

### METEO 491: JOINT NATIONAL WEATHER SERVICE MAP DISCUSSIONS

**Objectives for Meteo 491**

1. Students can demonstrate the ability to present an effective discussion and weather forecast based on current atmospheric conditions (relate to program objectives 1, 2, and 3)

**Outcomes for Meteo 491**

1. Students can demonstrate knowledge of the elements that are critical to creating an effective discussion and weather forecast based on current atmospheric conditions (relate to program outcomes a, b, c, and e)

### Develop Approaches to Measuring Outcomes: Identify activities/assignments that will provide a measure of achievement of specific program objectives and outcomes. Identify an approach for completing the evaluation and interpreting results.

**The Department will use the following metrics to evaluate program objectives:**

1. Exit surveys of students (at end of the student’s last semester)
2. Feedback from co-op and internship hosts and participating students (each fall semester)
3. Alumni interviews/survey at 3 and 6 years post matriculation

Meteo Objectives and Outcomes 8/31/2009

### Incorporate Results: Use results of above measurements/evaluation processes in course or curricular revisions.

1. Exit surveys prior to matriculation will be used to assess students’ academic/professional plans and preparedness for performance in their field.
2. Seeking feedback from internship hosts will demonstrate the preparedness of students and identify opportunities for curricular revisions in the context of stated program objectives
3. Interviews with alumni will provide data on success of the department’s curriculum, and will identify areas for growth/expansion

Communicate Assessment Plans: DUE Later in Year TBD
Listing program objectives in program description in Undergraduate Bulletin. Link from program home page to program objectives and outcomes measures.