

# METEOROLOGY AND ATMOSPHERIC SCIENCE

|                              |   |
|------------------------------|---|
| <b>Graduate Program Head</b> | Paul Markowski  |
| <b>Program Code</b>          | METEO   |
| <b>Campus(es)</b>            | University Park (Ph.D., M.S.)   |
| <b>Degrees Conferred</b>     | Doctor of Philosophy (Ph.D.)<br>Master of Science (M.S.)<br>Dual-Title Ph.D. in Meteorology and Atmospheric Science and Astrobiology<br>Dual-Title Ph.D. in Meteorology and Atmospheric Science and Climate Science<br>Integrated B.S. in Meteorology and Atmospheric Science and M.S. in Meteorology and Atmospheric Science |
| <b>The Graduate Faculty</b>  | View ( <a href="https://secure.gradsch.psu.edu/gpms/?searchType=fac&amp;prog=METEO">https://secure.gradsch.psu.edu/gpms/?searchType=fac&amp;prog=METEO</a> )  |

The graduate program embraces topics that span atmospheric processes from those of the planetary boundary layer to those of the upper atmosphere, that encompass phenomena from weather to climate with molecular to planetary dimensions, and that range from practical to theoretical significance. The program develops and integrates approaches based on observational, computational and analytical techniques, and seeks to advance both fundamental understanding and predictive skill.

The major interests of the faculty and graduate students include (1) mesoscale and synoptic-scale weather systems; (2) climate and earth system dynamics; (3) atmospheric physics including radiative transfer and cloud physics; (4) atmospheric chemistry, air quality and the earth's biogeochemical cycles; (5) atmospheric turbulence, boundary layers, land-atmosphere interactions, ocean-atmosphere interactions, and ocean-ice-atmosphere interactions; (6) geophysical fluid dynamics, (7) physical oceanography, (8) climate and weather risk, and (9) space weather. Methodological approaches include numerical modeling, data assimilation, atmospheric remote sensing, field observations, atmospheric data analysis, and laboratory studies.

## Admission Requirements

Applicants apply for admission to the program via the J. Jeffrey and Ann Marie Fox Graduate School application for admission (<https://gradschool.psu.edu/admissions/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<https://gradschool.psu.edu/graduate-education-policies/>).

The Meteorology and Atmospheric Science program is open to all students with a baccalaureate degree and a strong interest in the atmospheric sciences. A degree in science (including, but not limited to, meteorology or atmospheric science), mathematics, or engineering provides a particularly good background, although the department has had some students with arts and humanities degrees who have done well. The minimum course requirements for admission are mathematics

at least through differential equations and at least one year of calculus-based physics.

For admission to the program, the departmental admission committee considers courses taken, grade-point average, three letters of recommendation, professional experience, and English proficiency. Rather than setting rigid standards in each category, the committee examines the overall record as a whole. The best-qualified applicants are accepted up to the number of spaces that are available for new students.

Generally, additional mathematics and physics beyond the minimum requirements listed above, as well as courses in statistics, chemistry, and computer programming, will strengthen the student's application. Courses in meteorology and atmospheric science are not required for admission. Most students admitted to the graduate program have undergraduate grade-point averages of 3.50 or higher. Three recommendations are solicited from persons familiar with the student's academic competence, and the student is required to write a letter summarizing interests and goals.

The language of instruction at Penn State is English. English proficiency test scores (TOEFL/IELTS) may be required for international applicants. See GCAC-305 Admission Requirements for International Students (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/gcac-305-admission-requirements-international-students/>) for more information.

*Note:* All international students required to take the English proficiency test must take the American English Oral Communicative Proficiency Test (AEOCPT) (<http://aplng.la.psu.edu/programs/about-the-aeocpt/about-the-american-english-oral-communicative-test-aeocpt/>) upon first enrollment. If the student does not meet the minimum score requirements on the AEOCPT, the student must complete additional course work in English in order to be eligible to receive a teaching assistantship.

## Degree Requirements

The program differentiates between instruction and research topics appropriate for M.S. students seeking positions of advanced responsibility in government or industry, those appropriate for M.S. students anticipating further study, and those appropriate for Ph.D. candidates who will work in advanced research laboratories or academic institutions.

### Master of Science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<https://gradschool.psu.edu/graduate-education-policies/>)

The M.S. degree is offered with thesis or research paper options, both requiring 35 credits.

A minimum of 35 credits at the 400, 500, 600, or 800 level is required, with at least 29 credits at the 500, 600 and 800 level combined. The required core curriculum consists of 23 credits, including 12 credits in four distinct courses, two each from two prescribed lists for dynamic meteorology and physical meteorology:

| Code                    | Title | Credits |
|-------------------------|-------|---------|
| <b>Required Courses</b> |       |         |

#### *Dynamic Meteorology Courses*

Select two courses from the following:

|  |  |           |
|--|--|-----------|
| METEO 520  | Geophysical Fluid Dynamics                         |           |
| METEO 521  | Dynamic Meteorology                                |           |
| METEO 554  | Atmospheric Turbulence                             |           |
| METEO 551  | Physical Oceanography                              |           |
| METEO 570  | Climate System Dynamics                            |           |
| <i>Physical Meteorology Courses</i>  |  |           |
| Select two courses from the following:   |  | 6         |
| METEO 532  | Chemistry of the Atmosphere                        |           |
| METEO 533  | Cloud Physics                                      |           |
| METEO 535  | Radiative Transfer                                 |           |
| METEO 556  | The Atmospheric Boundary Layer                     |           |
| METEO 570  | Climate System Dynamics                            |           |
| <i>Additional Required Courses</i>   |  |           |
| METEO 880  | Communication of Research in Atmospheric Science   | 2         |
| or METEO 596   | Individual Studies                                 |           |
| METEO 590  | Colloquium   | 2         |
| METEO 591  | Development and Ethics in the Atmospheric Sciences | 1         |
| 6 elective credits from 500-level Meteorology and Atmospheric Science courses or 500-level courses in related disciplines from a list of approved electives maintained by the program office |  | 6         |
| <b>Total Credits</b>   |  | <b>23</b> |

Students can choose to complete either a thesis or a scholarly paper as the culminating experience for the degree. Students who choose the thesis track must select METEO 880 and 6 additional elective credits from 400- and 500-level course work in Meteorology and Atmospheric Science or related disciplines from a list of approved electives maintained by the program office. In addition, students must complete 6 quality-graded credits in thesis research (METEO 600 or METEO 610) in conjunction with completing the thesis (quality-graded credits count toward the grade-point average). The thesis must be accepted by the advisers and/or committee members, the head of the graduate program, and the Graduate School, and the student must pass a thesis defense.

Students in the scholarly paper track must select 2 credits of METEO 596, 6 additional elective credits from 400- and 500-level course work in Meteorology and Atmospheric Science, and 6 additional credits from 400- and 500-level course work in Meteorology and Atmospheric Science or related disciplines from a list of approved electives maintained by the program office. Students in the scholarly paper track cannot count METEO 600 credits towards degree requirements. Students will complete the scholarly paper while registered for 2 credits of METEO 596 in their final semester. M.S. students in the scholarly paper track must defend their scholarly paper in a public presentation that is evaluated by, and must be approved by, the students' committee.

## Doctor of Philosophy (Ph.D.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<https://gradschool.psu.edu/graduate-education-policies/>)

Studies for the Ph.D. degree are designed to accommodate the interests and capabilities of the student, and they are overseen by a Ph.D. committee, which also administers comprehensive and final oral examinations. The student must have the academic support of a faculty member and the student must pass the Ph.D. qualifying examination. The exam must be taken within three semesters (excluding summer

sessions) of entry into the doctoral program. If a student does not pass the exam on their first attempt, then a second attempt may be allowed at the discretion of the Graduate Faculty members of the department.

In addition, Ph.D. degree requirements include successful completion of the following: approved graduate course work, English competence requirements, a comprehensive examination, and a final oral examination (the dissertation defense). The student must pass the English competency exam before scheduling the comprehensive exam. To earn the Ph.D. degree, doctoral candidates must write a dissertation that is accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School. For the Ph.D. program, a minimum of 21 credits is required, including a core curriculum of 12 credits in four distinct courses, two each from two prescribed lists for dynamic meteorology and physical meteorology. The student will be tested for mastery of the selected core in the qualifying exam.

| Code   | Title   | Credits   |
|--|---|-----------|
| <b>Required Courses</b>  |   |           |
| <i>Dynamic Meteorology Courses</i>   |   |           |
| Select two courses from the following:   |   | 6         |
| METEO 520  | Geophysical Fluid Dynamics                                      |           |
| METEO 521  | Dynamic Meteorology   |           |
| METEO 554  | Atmospheric Turbulence  |           |
| METEO 551  | Physical Oceanography   |           |
| METEO 570  | Climate System Dynamics   |           |
| <i>Physical Meteorology Courses</i>  |   |           |
| Select two courses from the following:   |   | 6         |
| METEO 532  | Chemistry of the Atmosphere                                     |           |
| METEO 533  | Cloud Physics   |           |
| METEO 535  | Radiative Transfer  |           |
| METEO 556  | The Atmospheric Boundary Layer                                  |           |
| METEO 570  | Climate System Dynamics   |           |
| METEO 591  | Development and Ethics in the Atmospheric Sciences <sup>1</sup> | 1         |
| METEO 880  | Communication of Research in Atmospheric Science <sup>2</sup>   | 2         |
| <b>Electives</b>   |   |           |
| A minimum of 6 elective credits from METEO 500-level or related discipline 400- or 500-level courses must be taken that do not count toward any other degree requirement and finished by the semester in which the comprehensive exam is passed. |   | 6         |
| <b>Total Credits</b>   |   | <b>21</b> |

<sup>1</sup> Students must take METEO 591 the first semester it is available upon matriculating in the program.

<sup>2</sup> METEO 880 must be taken prior to the department's competency exam in written and spoken technical English.

<sup>3</sup> One credit of METEO 590 is required each semester until the comprehensive exam is passed.

The 12 credits of core curriculum courses, METEO 880, and METEO 591 may be waived as required courses at the discretion of the program if the student has already taken them or equivalent courses, and the total required credits will be reduced accordingly. In addition to the 21 minimum required credits, one credit of METEO 590 is required each semester until the comprehensive exam is passed. A student must pass the department's competency exam in written and spoken technical

English before being admitted to the comprehensive exam. There are no minimum quality-graded credit (research credits whose grades count toward the grade-point average) requirements for METEO 600; students may earn up to a maximum of 12 quality-graded METEO 600 credits.

## Minor Master's Minor

Requirements listed here are in addition to requirements for minors in Graduate Council policy GCAC-218 Minors (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-218-minors/>).

For a master's minor in Meteorology and Atmospheric Science, a student must select 6 credits of Meteorology and Atmospheric Science courses, 3 of which have to be at the 500-level, in a course plan approved by the Meteorology and Atmospheric Science graduate program.

## Doctoral Minor

Requirements listed here are in addition to requirements for minors in Graduate Council policies listed under GCAC-600 Research Degree Policies (<https://gradschool.psu.edu/graduate-education-policies/>) and GCAC-700 Professional Degree Policies (<https://gradschool.psu.edu/graduate-education-policies/>).

For a minor in Meteorology and Atmospheric Science, doctoral students should select 15 credits of Meteorology and Atmospheric Science courses, 9 credits of which have to be 500-level, in a course plan approved by the department.

## Dual-Titles Dual-Title Ph.D. in Meteorology and Atmospheric Science and Astrobiology

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-titles/>).

Students interested in the emerging field of Astrobiology may wish to obtain a dual-title Ph.D. in Meteorology and Atmospheric Science and Astrobiology. The pursuit of this dual-title entails additional course work beyond the degree requirements set forth here (see the Astrobiology Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/astrobiology/>) for further details concerning these course and other program requirements), as well as the participation of at least one Astrobiology program faculty member on the Ph.D. committee. The Astrobiology representative, who assists with the selection of courses, may be the adviser and have an appointment in Meteorology and Atmospheric Science. The field of Astrobiology will be integrated into the comprehensive examination. A Ph.D. dissertation that contributes fundamentally to the field of Astrobiology is required. A public oral presentation of the dissertation is required.

### Admission Requirements

Students must apply and be admitted to the graduate program in Meteorology and Atmospheric Science and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the Astrobiology dual-title program. Refer to the Admission Requirements section of the Astrobiology Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/astrobiology/>). Doctoral students must be admitted into the dual-title degree program in Astrobiology no later than the end of

the fourth semester (not counting summer semesters) of entry into the graduate major program.

### Degree Requirements

To qualify for the dual-title degree, students must satisfy the degree requirements for the Ph.D. in Meteorology and Atmospheric Science. In addition, students must complete the degree requirements for the dual-title in Astrobiology, listed on the Astrobiology Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/astrobiology/>).

The Qualifying Examination in the major area alone will satisfy the Qualifying Exam requirement for the dual-title program.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>), the Ph.D. committee of a Meteorology and Atmospheric Science and Astrobiology dual-title Ph.D. student must include at least one member of the Astrobiology Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in Astrobiology, the member of the committee representing Astrobiology must be appointed as co-chair. The Astrobiology representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in Meteorology and Atmospheric Science and Astrobiology. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

## Dual-Title Ph.D. in Meteorology and Atmospheric Science and Climate Science

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-titles/>).

Students interested in the field of Climate Science may wish to obtain a dual-title Ph.D. in Climate Science and Meteorology and Atmospheric Science. The pursuit of this dual-title entails additional course work beyond the degree requirements set forth here (see the Climate Science Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/climate-science/>) for further details concerning these course and other program requirements), as well as the participation of at least one Climate Science program faculty member on the Ph.D. committee. The Climate Science representative, who assists with the selection of courses, may be the adviser and have an appointment in Meteorology and Atmospheric Science. The field of Climate Science will be integrated into the comprehensive examination. A Ph.D. dissertation that contributes fundamentally to the field of Climate Science is required. A public oral presentation of the dissertation is required.

### Admission Requirements

Students must apply and be admitted to the graduate program in Meteorology and Atmospheric Science and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission

to and meet the admissions requirements of the Climate Science dual-title program. Refer to the Admission Requirements section of the Climate Science Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/climate-science/>). Doctoral students must be admitted into the dual-title degree program in Climate Science no later than the end of the fourth semester (not counting summer semesters) of entry into the primary Ph.D. program.

### **Degree Requirements**

To qualify for the dual-title degree, students must satisfy the degree requirements for the Ph.D. in Meteorology and Atmospheric Science. In addition, students must complete the degree requirements for the dual-title in Climate Science, listed on the Climate Science Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/climate-science/>).

The qualifying examination in Meteorology and Atmospheric Science satisfies the qualifying exam requirement for the dual-title degree program in Climate Science.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>), the Ph.D. committee of a Meteorology and Atmospheric Science and Climate Science dual-title Ph.D. student must include at least one member of the Climate Science Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in Climate Science, the member of the committee representing Climate Science must be appointed as co-chair. The Climate Science representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in Meteorology and Atmospheric Science and Climate Science. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

## **Integrated Undergrad-Grad Programs**

### **Integrated B.S. in Meteorology and Atmospheric Science and M.S. in Meteorology and Atmospheric Science**

This Integrated Undergraduate/Graduate (IUG) degree program combines the B.S. in Meteorology and Atmospheric Science with the M.S. in Meteorology and Atmospheric Science offered at the following campuses:

#### **Undergraduate Degree**

- University Park

#### **Graduate Degree**

- University Park

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<https://gradschool.psu.edu/graduate-education-policies/gcac/>

[gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs/](https://gradschool.psu.edu/graduate-education-policies/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs/)).

The Department of Meteorology and Atmospheric Science offers an integrated B.S./M.S. program, also called the Integrated Undergraduate-Graduate (IUG) program, that is designed to allow academically superior students to obtain both the B.S. and the M.S. degree in Meteorology and Atmospheric Science in five years of study. In order to complete the program in five years, students interested in the IUG program in Meteorology and Atmospheric Science must apply for admission to the Graduate School and the IUG program no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate degree.

During the first three years, the student will follow the course scheduling of one of the options in the B.S. degree, normally the Atmospheric Sciences or the General Option (see the Undergraduate Bulletin (<http://bulletins.psu.edu/undergraduate/>)). Students who intend to enter the IUG program are encouraged to take upper level classes during their first three years whenever appropriate. However, students must sequence their courses so all undergraduate degree requirements are fulfilled before taking courses to count solely towards the graduate degree. By the end of the junior year, students normally apply for admission to both the IUG Program and to the Graduate School. Acceptance decisions will be made prior to the beginning of the senior year and M.S. advising committees appointed for successful applicants. During the senior year, IUG students follow the scheduling of the selected B.S. Meteorology and Atmospheric Science Option, with an emphasis on completing 500-level course work as appropriate. During the senior year, IUG students will start work on their theses or papers that are designed to meet the requirements of the M.S. degree in Meteorology and Atmospheric Science. During the fifth year, IUG students take courses fulfilling the departmental M.S. degree requirements and complete their M.S. theses or papers. Typical scheduling plans for students pursuing the General or Atmospheric Sciences Options are given on the Meteorology and Atmospheric Science Undergraduate Bulletin page (<http://undergraduate.bulletins.psu.edu/undergraduate/colleges/earth-mineral-sciences/meteorology-atmospheric-science-bs/>). If a plan similar to one of these plans is followed, then the student will have completed all requirements for the B.S. in Meteorology and Atmospheric Science by the end of the fourth year. If a student cannot continue in the integrated program, then the student will be able to receive the undergraduate degree upon completion of all of the B.S. requirements.

### **Admission Requirements**

Applicants apply for admission to the program via the Graduate School application for admission (<https://gradschool.psu.edu/graduate-admissions/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<https://gradschool.psu.edu/graduate-education-policies/>).

Students must apply to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply/>), and must meet all the admission requirements of the Graduate School and the Meteorology and Atmospheric Science graduate program for the Master of Science degree. In consultation with an adviser, students must prepare a plan of study appropriate to this integrated program, and must present their plan of study to the head of the graduate program or the appropriate committee overseeing the integrated program prior to being admitted to the program. The plan should cover the entire time period of the integrated program, and it

should be reviewed periodically with an adviser as the student advances through the program.

Before applying to the Graduate School, students must have completed entrance to their undergraduate major and have completed no less than 60 credits. Students must be admitted no later than the end of the second week of the semester preceding the semester of expected conferral of the undergraduate degree. Transfer students must have completed at least 15 credits at Penn State to enroll in an IUG. Admission to the program will be at the discretion of the Associate Head of the Department of Meteorology and Atmospheric Science graduate program, who will determine the necessary criteria for all applicants. These criteria include the setting of the minimum required scores on the GRE and minimum cumulative GPA for consideration, the receipt of recommendation letters from three faculty and a letter of support from the department head, and the identification of an adviser who is willing to oversee the student's research project. Evidence of significant research potential must be provided in the application.

### Degree Requirements

Students must fulfill all degree requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined below. Degree requirements for the Bachelor of Science in Meteorology and Atmospheric Science are listed in the Undergraduate Bulletin (<http://bulletins.psu.edu/undergraduate/>). Degree requirements for the Master of Science in Meteorology and Atmospheric Science are listed on the Degree Requirements tab. All IUG students must defend their theses or papers, as do all M.S. students, in a public presentation toward the end of their graduate program.

Up to 12 credits may be double-counted towards the degree requirements for both the graduate and undergraduate degrees; a minimum of 50% of the double-counted courses must be at the 500 or 800 level. Independent study courses and credits associated with the culminating experience for the graduate degree cannot be double-counted.

| Code   | Title                          | Credits |
|--|--------------------------------|---------|
| <b>Courses Eligible to Double Count for Both Degrees</b> |                                |         |
| METEO 520  | Geophysical Fluid Dynamics     | 3       |
| METEO 521  | Dynamic Meteorology            | 3       |
| METEO 532  | Chemistry of the Atmosphere    | 3       |
| METEO 533  | Cloud Physics                  | 3       |
| METEO 535  | Radiative Transfer             | 3       |
| METEO 554  | Atmospheric Turbulence         | 3       |
| METEO 551  | Physical Oceanography          | 3       |
| METEO 556  | The Atmospheric Boundary Layer | 3       |
| METEO 570  | Climate System Dynamics        | 3       |

Students must sequence their courses so all undergraduate degree requirements are fulfilled before taking courses to count solely towards the graduate degree. Students are expected to complete the undergraduate degree requirements within the typical time to degree for the undergraduate major. In the semester in which the undergraduate degree requirements will be completed, IUG students must apply to graduate, and the undergraduate degree should be conferred at the next appropriate Commencement.

## Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (<https://gradschool.psu.edu/funding/>) section of the J. Jeffrey and Ann Marie Fox

Graduate School's website. Students on graduate assistantships must adhere to the course load limits (<https://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/>) set by the Fox Graduate School.

Most graduate students are supported with teaching or research assistantships.

## Courses

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Meteorology (METEO) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/meteo/>)

## Learning Outcomes

### MAster of Science (M.S.)

1. Know: Graduates will acquire and demonstrate mastery of knowledge within a core disciplinary area of the atmospheric sciences while demonstrating familiarity with other topics within the atmospheric sciences outside of the core area.
2. Investigate: Graduates will develop analytical and methodological skills necessary to apply knowledge of the atmospheric sciences to the solution of an unanswered problem within the discipline.
3. Communicate: Graduates will disseminate results of investigation via a logically, clearly written master's thesis, and via articulate, effective presentations.
4. Professional practice: Graduates will demonstrate the ability to collaborate in a collegial and ethical manner with other professionals within their field or with diverse scientific backgrounds.

### Doctor of Philosophy (Ph.D.)

1. Know: Graduates will demonstrate in-depth knowledge within a core disciplinary area of atmospheric science while extending their depth of knowledge on other topical areas within the atmospheric sciences.
2. Investigate: Graduates will master analytical and methodological skills necessary to pursue solutions to unanswered problems within the atmospheric sciences independently.
3. Communicate: Graduates will disseminate research results of investigations through a logically, clearly written doctoral thesis, and through articulate, effective presentations.
4. Professional practice: Graduates will demonstrate the ability to collaborate in a collegial and ethical manner with other professionals in their field or with diverse scientific backgrounds.

## Contact

|  |  |
|--|--|
| <b>Campus</b>  | University Park  |
| <b>Graduate Program Head</b>   | Paul Markowski   |
| <b>Director of Graduate Studies (DGS)<br/>or Professor-in-Charge (PIC)</b> | Jerry Y Harrington   |
| <b>Program Contact</b>   | Karen Corl<br>501A Walker Building<br>375 Steam Drive<br>University Park PA 16802<br>kqc8@psu.edu<br>(814) 863-9500                                      |
| <b>Program Website</b>   | View ( <a href="http://www.met.psu.edu/future-graduate-students-ms-and-phd/">http://www.met.psu.edu/<br/>future-graduate-students-ms-and-<br/>phd/</a> ) |