

<u>AMS subject area</u>	<u>course ID</u>	<u>title</u>	<u>required by NCSU</u>	<u>required by AMS</u>	<u>required by NWS</u>	
thermodynamics and dynamics	MEA312	Atmos Thermodyn	yes	yes	yes	
	MEA421	Atmos Dynamics I	yes	yes	yes	
	MEA422	Atmos Dynamics II	yes	yes	no (only 6 hours)	
atmospheric physics	MEA412	Atmos Physics	yes	yes	yes	
synoptic meteorology	MEA443	Wea Analysis & Fcstg I	yes	yes	yes	
mesoscale meteorology	MEA444	Wea Analysis & Fcstg II	no	no	yes	
measurements/remote sensing	(MEA512)	Satellite Met	(no)			
	(MEA513)	Radar Met	(no)			
	MEA593O	Remote Sensing	no	yes (3 hours)	yes (2 hours)	←
integrative approach to the environment	MEA311	Global Atmosphere	yes		no	?
	group 920	Sci., Tech. & Society elective	yes	yes (one course)	no	?
MEA electives	MEA***	advised and restricted electives	12 hours	6 hours	9 hours	
other courses outside MEAS	CH101	Chemistry "A Molecular Sci"	yes	yes	no	
	CH201	Chemistry "A Quantitative Sci"	yes	no	no	←
	ENG333	Commun for Sci & Res	yes	yes	no	
	MA141	Calculus I	yes	(pre-req)	(pre-req)	
	MA241	Calculus II	yes	yes	(pre-req)	
	MA242	Calculus III	yes	yes	(pre-req)	
	MA341	Appl Diff Eq I	yes	yes	yes	
	PY205	Physics I	yes	yes	yes	
	PY208	Physics II	yes	yes	yes	
	ST380	Prob & Stats for Phys Sci	yes	yes	no	
	group 201	Comp Sci elective	yes	yes	no	

Recommended electives for undergraduate students who want to specialize

<u>AMS specialized topic area</u>	<u>course ID</u>	<u>course title</u>
advanced dynamics	?	
agricultural meteorology	?	
air pollution meteorology	MEA320	Fundamentals of Air Pollution
	MEA455	Micrometeorology
	MEA479	Air Quality
applied climatology	?	
aviation meteorology	?	
broadcast meteorology	JOMC21 @ UNC	Writing for Electronic Media
	JOMC120 @ UNC	Intro to Video Prod and Editing
	JOMC121 @ UNC	Electronic Journalism
	JOMC122 @ UNC	Producing Television News
hydrology or hydrometeorology	MEA467?	Marine Meteorology
	<i>others?</i>	<i>(in CivEng/Forestry/Soils???)</i>
	<i>??????</i>	<i>AMS recommends a course in GIS</i>
physical oceanography	MEA200	Intro to Oceanography
	MEA460	Physical Oceanography
	MEA462	Obs. Methods in Marine Physics
	MEA463	Fluid Physics
	MEA464	Ocean Circulation Systems
	MEA467	Marine Meteorology
tropical meteorology	MEA593T	Tropical Meteorology
weather forecasting	MEA444*	Weather Analysis and Forecasting II
=required for NWS	MEA493O	Remote Sensing
	MEA455	Micrometeorology
	MEA467	Marine Meteorology
	MEA593T	Tropical Meteorology

Bachelor's Degree in Atmospheric Science

(Adopted by AMS Council on 29 April 2005) *Bull. Amer. Met. Soc.*, **86**

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1. Introduction

The primary purpose of this statement is to provide guidance to university faculty and administrators who are seeking to establish and maintain undergraduate programs in atmospheric science. This statement describes the minimum curricular composition, faculty size, and facility requirements recommended by the American Meteorological Society for an undergraduate degree program in atmospheric science. It also provides information that may be helpful to prospective students who are exploring educational alternatives in atmospheric science. Although the focus of this statement is deliberately on curricular composition and course offerings, it must be recognized that the content, format, and methods used for teaching those courses are important factors in student outcomes and their preparedness for future careers. For example, courses with more hands-on experiences can have a considerable impact on student learning.

A contemporary academic program in atmospheric science must provide students with a fundamental background in basic atmospheric and related sciences, mathematics, and statistics. It must also provide flexibility and breadth so that students can prepare to pursue a variety of professional career paths. Along the way to their graduation, students must acquire an appropriate mix of fundamental knowledge, core competencies, and skills needed to compete and succeed in a variety of atmospheric science-related careers. While emphasizing fundamental knowledge in atmospheric science, the curriculum should also consider the fact that many of the significant problems facing the world today deal with the interaction of processes that span multiple domains in natural, physical, and mathematical sciences. Atmospheric science courses must also provide students ample opportunity for developing communication and critical thinking skills, including problem solving, reasoning, analytic and other relevant professional skills.

Computers and information technologies are now playing a central role in this complex and ever-changing world in which we live and work, with the Internet reshaping almost every aspect of life, including education and commerce. More than ever, educators, students and their future employers recognize the importance of computer literacy and information technology (IT) skills. To meet those expectations, atmospheric science programs must help students build a seamless pathway from the classroom to productive careers in atmospheric and related fields and prepare them for today's increasingly IT-driven and global society. Specifically, computer programming and other computer-related skills should be integrated, as appropriate, into as many atmospheric science courses as feasible.

Also due to the rapid advances in computer and communication technologies, students will encounter frequent and inevitable changes in the types and forms of technologies with which they will interact and the ways in which they will use them when they join the workforce. Undergraduate atmospheric science education, therefore, should also be designed to develop student talents that provide them the necessary versatility for long-term success in an evolving profession.

The program attributes listed in [section 2](#) are those common to any career in atmospheric science. Additional coursework may be helpful for gaining entry to some specific career paths; suggestions are given in Appendix A for a few selected careers.

While many similarities exist, the curricular program described in [section 2](#) differs from that required for employment as a meteorologist by the federal government ([see Appendix B](#) for current federal civil service requirements). Although the federal requirements provide excellent guidelines for preparation for a career in operational weather forecasting, university academic requirements are designed to support a broader spectrum of career options.

2. Attributes of bachelor's degree programs

a. General objectives

The objectives of a bachelor's degree program in atmospheric science should include strong preparation for:

- 1) a successful career in atmospheric science or a closely related field through a combination of in-depth education and the development of a range of relevant professional skills; *or*
- 2) graduate study in atmospheric and related sciences through in-depth education and focus on critical thinking, problem solving, reasoning, and analytic and other scientific skills.

b. Course offerings

A curriculum leading to a Bachelor of Science or Bachelor of Arts degree in atmospheric science should contain

- 1) at least 24 semester hours 2 of credit in atmospheric science courses that include the following:
 - 12 semester hours of lecture and laboratory courses, with calculus as a prerequisite or corequisite 3, in atmospheric thermodynamics and dynamic, synoptic, and mesoscale meteorology that collectively provide a broad treatment of atmospheric processes at all scales;
 - 3 semester hours of atmospheric physics, with emphasis on cloud/precipitation physics and solar and terrestrial radiation 3;
 - 3 semester hours of atmospheric measurements, instrumentation, or remote sensing, including both lecture and laboratory components;
 - at least 3 semester hours in applied/specialty meteorology topics such as:

- advanced dynamics, agricultural meteorology, air pollution meteorology, applied climatology, aviation meteorology, broadcast meteorology, hydrology or hydrometeorology, physical oceanography, tropical meteorology, and weather forecasting;
 - up to 3 semester hours of a synthesizing experience 4 such as
 - an undergraduate research project
 - a capstone course;
 - an internship focused on a career in atmospheric science or a closely related field; or
 - work experience closely related to the atmospheric sciences;
- 2) a minimum of a three-semester sequence of calculus that includes vector calculus and ordinary differential equations, in courses designed for majors in either mathematics, physical sciences or engineering;
- 3) a one-year sequence in physics lecture and laboratory courses, with calculus as a prerequisite or corequisite;
- 4) at least one course (3 semester hours) in chemistry appropriate for physical science majors;
- 5) a course with a multi-disciplinary and/or integrative approach to an environmental topic, such as a course on climate change;
- 6) an appropriate level of coursework or demonstrated competency in the following areas:
- computer science or information technology appropriate for physical science majors, including a course that teaches scientific, structured programming skills;
 - statistics appropriate for physical science majors;
 - technical, scientific, and professional writing, and oral communication;

Whenever possible and where appropriate, course requirements should include components that utilize modern computer and instrumentation labs and facilities.

As in any science curriculum, students should have the opportunity and be encouraged to supplement minimum requirements with additional course work in the major and supporting areas. This supplemental course work may include courses designed to broaden the student's perspective on the earth as a system, the environmental sciences, science administration, ethics, history of science, and policy making, as well as additional courses in the basic sciences, mathematics, statistics, and engineering. Also, students should be strongly urged to supplement their atmospheric science course work with additional courses or other activities designed to develop effective communication skills, both written and oral.

The use of computers and numerical models in the atmospheric sciences has increased dramatically in recent years. Students should be strongly encouraged to build skills in computer programming, graphic and web design, data manipulation, statistics, and numerical modeling. Students with strong backgrounds in statistics and computer science will be especially well-positioned to contribute to the advancement of the atmospheric sciences within most specialty areas.

Finally, as noted in the introduction, the curriculum described above differs from federal civil service requirements (see [Appendix B](#)). However, it is recommended that courses required to fulfill federal employment requirements—even if not required for the curriculum—be made available. Further, if the offering of such courses is not consistent with the educational objectives of the program, then the institution has an obligation to inform prospective students that the completion of their undergraduate degree will not fully qualify them for entry-level employment in federal agencies.

c. Faculty

There should be a minimum of three full-time regular faculty with expertise sufficiently broad to address the subject areas identified in item 1 in [section 2b](#). This recommendation assumes a regular faculty teaching load of three or more courses per semester. For those departments where atmospheric science faculty are expected to carry out an active research program, it is recommended that the minimum number of departmental faculty be increased concomitant with the university's research expectations. University administrators should also bear in mind when considering the desired number of atmospheric faculty at their institution the integral role of atmospheric science in the physical and environmental sciences and the considerable potential for extramural support in the atmospheric sciences.

The faculty role should extend beyond teaching and research to include mentoring of students with diverse educational and cultural backgrounds. Departments and programs are also encouraged to emphasize increasing the diversity of their faculty, as an important and visible component of an overall commitment to diversity.

d. Facilities

There should be sufficient and coherent space for the atmospheric science program and its students. Contained within this space should be instructional labs and facilities to foster excellence in teaching and learning and to accommodate the changing needs of today's student population. Atmospheric science programs should maintain labs where real-time and archived meteorological data can be accessed through computer-based data acquisition and display systems, along with indoor and outdoor facilities suitable for teaching meteorological observation, instrumentation, and measurement techniques.

- Whenever possible, faculty should make use of modern instructional facilities, either within their department or elsewhere within the institution, that contain computerized instructional aids, internet connectivity, and appropriate projection equipment for teaching their courses. Such facilities allow faculty to use the rapidly expanding suite of multi-media offerings now available either on the World Wide Web or on CD-ROMs for teaching atmospheric science courses.

To support the courses in section 2b, the atmospheric science program should provide students with appropriate tools, applications software, and simple or idealized computer models suitable for learning about dynamical and physical processes in the atmosphere.

e. Student recruitment and retention

The number of students from traditionally underrepresented groups in the atmospheric sciences continues to be alarmingly low. Ideally, atmospheric science programs should reflect the full diversity of the general population. To that end, atmospheric science programs should work with their institutions, community colleges, and secondary schools to develop resources and procedures that support recruitment and retention of diverse students. Programs should nurture and promote an academic culture that is deeply supportive of and committed to diversity. Efforts aimed at increasing the participation of traditionally under-represented students in the atmospheric sciences, such as identification and implementation of best practices and procedures that most successfully result in achieving the diversity goals, should become a continuing priority.

Appendix A: Preparation for selected careers in atmospheric science

This section provides advice about additional courses that could be useful for those students who wish to pursue a specific career path in atmospheric science. The careers listed cover only a small fraction of the professional employment opportunities in atmospheric science. Since this statement is concerned with the bachelor's degree and students already have many course requirements, only a few additional courses are listed per career. It is not intended to be an exhaustive list of all courses that could be useful for a particular career.

Students should keep in mind that many of the suggested courses may have prerequisites that are not listed here and that may vary from institution to institution.

As a general rule, performing an internship in the area of interest and/or completion of an undergraduate research project on a topic in the area are excellent complements to the additional courses listed here and fulfill the recommended synthesizing experience listed under item 2b.

a. Weather forecasting careers

Students intending to enter this career field should consider including the following course work or types of experiences in their program of study:

- 1) three courses in synoptic and mesoscale meteorology, to include an introduction to numerical weather prediction (these courses would include courses recommended in basic requirements under item 1 of [section 2b](#));
- 2) a course in operational weather analysis and forecasting techniques that includes a laboratory component; and
- 3) a remote sensing course in either satellite or radar meteorology that includes a laboratory component (such a course would also meet the basic requirements under item 1 of [section 2b](#)).

b. Media careers, including those in Broadcast Meteorology

Students intending to enter this career field should consider including the following course work or types of experiences in their program of study:

- 1) a course in operational weather analysis and forecasting techniques;

- 2) one or more courses in communication, journalism, writing, and speech; and
 - 3) one or more courses in publishing or broadcast media and broadcasting.
- In addition, students pursuing a Broadcast Meteorology career track should become familiar with the requirements and procedures for gaining certification, such as the American Meteorology Society's Certified Broadcast Meteorologist program.

c. Hydrometeorology careers

Students intending to enter this career field should consider including the following course work or types of experiences in their program of study:

- 1) a course in hydrology, fluid mechanics or fluid dynamics;
- 2) a course in hydrometeorology or precipitation processes;
- 3) a course in radar meteorology that includes radar observations of meteorological phenomena; and
- 4) a course in Geographic Information Systems.

d. Environmental monitoring careers

Students intending to enter this career field should consider including a select subset of the following course work or types of experiences in their program of study:

- 1) an additional chemistry course (in most schools this course would be a continuation of the course used to meet the requirement for a chemistry course in item 4 of [section 2b](#));
- 2) a course in atmospheric or environmental chemistry;
- 3) a course in atmospheric turbulence, micrometeorology, or boundary layer meteorology;
- 4) an air pollution meteorology course having courses such as items 2 and 3 above as prerequisites;
- 5) a course involving dispersion analysis and the use of air quality models;
- 6) a course in climate change or climatology; and/or
- 7) a course in earth-system science, biometeorology, or oceanography.

e. Careers in Support of Transportation, including Aviation Meteorology

Students intending to enter this career field should consider including the following course work or types of experiences in their program of study:

- 1) a course in fluid mechanics;

- 2) a course in aviation meteorology, including a basic understanding of turbulence and aircraft icing;
- 3) a course in weather analysis and forecasting;
- 4) a course in weather information systems or aircraft systems and instruments; and
- 5) an additional course in advanced thermodynamics or physical meteorology.

f. Business-related careers

Students intending to have a career in private sector or commercial meteorology should consider the following coursework:

- a course in economics;
- a course in marketing;
- a course in organization principles and management;
- a course in information systems;
- either a course in organizational behavior and human behavior, or one in entrepreneurship or small business management; and
- a course in strategic planning, program evaluation, or budget formulation and execution.

g. Preparation for graduate studies and research positions

Students intending to continue their academic careers with a graduate degree (MS or PhD) before pursuing a career should consider including the following course work or types of experiences in their program of study:

- 1) additional mathematics courses, such as advanced calculus, partial differential equations, and linear algebra;
- 2) additional atmospheric science courses in dynamics, physical meteorology, mesoscale and synoptic meteorology, climate change, or remote sensing;
- 3) a course in numerical methods or computational fluid dynamics;
- 4) a course in statistics and probability theory; and
- 5) additional scientific computer programming courses. It should be noted that FORTRAN continues to be the preferred programming language for developing many atmospheric science applications, including numerical modeling and data assimilation.

h. K-12 teaching careers

Students intending to enter the teaching profession should consider elective coursework related to their chosen area of specialization, which might include earth science, physical science, general science, or mathematics. Students may pursue provisional middle- or high-school teaching certification with the BS degree in Atmospheric Sciences, as determined by state education rules. Students could include the following

coursework or types of experiences in their program of study:

- Educational foundations, theory, and practice; educational psychology (appropriate for level, following state guidelines)
- General Science: coursework in Biology and expanded coursework in Chemistry, Geoscience, and/or Physics
- Earth Science: additional coursework in geology, hydrology, oceanography, and astronomy
- Physical Science: additional coursework in chemistry, physics, and astronomy
- Mathematics: additional coursework in mathematics such as geometry, logic, linear algebra

i. Military Weather Officer careers

Military Weather Officers initially work in forecast intensive assignments, then enter a graduate school MS program and work in more management and leadership roles in the later stages of their military career. Students intending to enter the military, as an Air Force Weather Officer or Navy Meteorology and Oceanography (METOC) Officer, should consider including some of the course work outlined in section a. (Weather forecasting careers) and section i. (Preparation for graduate studies and research positions) in their program of study. A course in Physical Oceanography would be helpful for those students most interested in the Navy METOC program.

Appendix B: Federal civil service requirements for meteorologist positions (GS 1340, effective 1 March 1998)

The requirements for federal employment as a meteorologist are given below. To meet these requirements, students should ensure that the 12 credits of course work in atmospheric thermodynamics and dynamics and weather analysis and forecasting recommended in section 2 of this statement include six semester hours of dynamic

meteorology and six semester hours of weather analysis and forecasting.

A. A degree in meteorology, atmospheric science, or other natural science major that includes the following:

1) At least 24 semester hours (36 quarter hours) of credit in meteorology/atmospheric science, including a minimum of

a) 6 semester hours in atmospheric dynamics and thermodynamics 5,

b) 6 semester hours in analysis and prediction of weather systems (synoptic/mesoscale),

c) 3 semester hours of physical meteorology, and

d) 2 semester hours of remote sensing of the atmosphere and/or instrumentation;

2) 6 semester hours of physics, with at least one course that includes laboratory session *;

3) 3 semester hours of ordinary differential equations *; and

4) at least 9 semester hours of course work for a physical science major in any combination of three or more of the following: physical hydrology, chemistry, physical oceanography, physical climatology, radiative transfer, aeronomy, advanced thermodynamics, advanced electricity and magnetism, statistics, light and optics, and computer science.

Or

B. A combination of education and experience-course work shown in A above, plus appropriate experience or additional education.

1 For the purposes of this document, the terms "atmospheric science" and "meteorology" are taken to be equivalent.

2 Some institutions use a quarter system rather than the semester system. Normally, two semester hours equates to three quarter hours. In some cases, the recommended credits in section 2b may convert to noninteger numbers of quarter hours. In such cases, the institutions may combine a course with an appropriate portion of another course to meet the recommendation.

3 There is a prerequisite or corequisite of calculus for course work in atmospheric dynamics and thermodynamics, physics, and differential equations. Calculus courses must be appropriate for a physical science major. The preferred sequence of courses is for students to enroll in atmospheric thermodynamics and dynamics courses after completing at least two semesters of calculus.

4 This requirement is assigned a range of credit hours (i.e., 0-3 credits) in acknowledgement that many cooperative and internship experiences, such as the NWS Student Career or Temporary Employment Programs that offer participants work experience directly related to their academic field of study, are salaried and consequently at most colleges and universities students cannot earn credit hours for

these synthesizing and capstone work experiences.

5 There is a prerequisite or corequisite of calculus for course work in atmospheric dynamics and thermodynamics, physics, and differential equations. Calculus courses must be appropriate for a physical science major.

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Headquarters: 45 Beacon Street, Boston, MA 02108-3693

Email: amsinfo@ametsoc.org

Phone: 617-227-2425; Fax: 617-742-8718