June 19, 2009

W. Randy Smith, Vice Provost
Office of Academic Affairs
203 Bricker Hall, 190 N. Oval Mall
CAMPUS

Dear Randy:

On May 29, 2009, the Arts and Sciences Committee on Curriculum and Instruction (CCI) unanimously approved a series of significant changes to the Geography undergraduate curriculum which includes:

1. Revisions to the structure and names of 4 existing tracks within the current Geography major
   - Revision to the BS in Analytical Cartography and Geographical Information Systems
     - proposed new name: Spatial Analysis
   - Revision to the BS in Atmospheric and Climatic Studies
     - proposed new name: Climatology and Physical Geography
   - Revision to the BA in Urban and Regional Studies
     - proposed new name: Urban, Regional and Global Studies
   - Revision to the BA in People, Society and Environment
     - proposed new name: Environment and Society

2. Establishment of two new Bachelor of Science Majors
   - New BS in Geographic Information Science
   - New BS in Atmospheric Sciences

Please see the accompanying cover letter from Associate Dean Gene Mumy (p 2-7) which provides a detailed summary of the proposal including credit hour changes. The transmittal history provided includes detailed minutes from meetings of the SBS College Curriculum Committee, the CCI Sciences Subcommittee, and the A&S CCI over the past year which may also prove helpful in vetting this proposal at the CAA level (p 114-130). The numerous syllabi and course requests associated with these proposals are in the ECA system pending the approval of the program proposals by CAA. Below is a list of the course requests in ECA associated with this proposal.

The crucial issue of concurrence from the School of Earth Science was resolved before the proposal was approved by CCI. This packet includes original documentation of key correspondence between Earth Science and Geography (p 131-135) in order to provide background information to the committee. The final official concurrence from Earth Science is included on page 113. A related issue that arose at the CCI discussion concerned the status of the Major in Mapping and Land Information Systems, housed in the School of Earth Sciences, which currently has no majors. On May 29, representatives from Geography indicated that they would have no objections to Earth Sciences reviving this major in principle and would want to work with them to ensure that the major is distinctive from any Geography majors or tracks.
Please let me know if I can be of further assistance as CAA considers this proposal.

Sincerely,

Kathleen M. Hallihan
Director, Curriculum and Assessment

c: Randy Smith
   Melissa Soave
   Terry Gustafson

**New courses:**
- Geog 205
- Geog 420
- Geog 455
- Geog 470
- Geog 480
- Geog 505
- Geog 600
- Geog 684
- Geog 688
- Atmospheric Sci 689
- Atmospheric Sci 699
- Atmospheric Sci H783

**Course changes:**
- Geog 200
- Geog 240
- Geog 400
- Geog 430
- Geog 445
- Geog 460
- Geog 490
- Geog 510
- Geog 605
- Geog 630
- Geog 640
- Geog 642
- Geog 650
- Geog 652
- Geog 655
- Geog 680
- Geog 683
- Geog 686
- Geog 687
- Geog 695
- Atmospheric Sci 637
Geography curriculum revision and new major proposal:
Breakdown of distribution of quarter credit hours by major and specialization

<table>
<thead>
<tr>
<th>Major and specialization</th>
<th>Core (all majors)</th>
<th>Core (specialization)</th>
<th>Major electives</th>
<th>Total major</th>
<th>Non-Geog prereq</th>
<th>Total major + prereq</th>
<th>GEC</th>
<th>GEC double counts</th>
<th>Free electives</th>
<th>Total</th>
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<td>27-31</td>
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Notes
1. The actual GEC is 80-100 hours because of the language requirement variation of 0 to 20 hours. The 90 hours used in the table assumes a typical student would be taking 10 hours of foreign language.
2. GEC double counts: Because of requirements in math, physics, and chemistry, the Climate and Physical Geography (CPG) specialization and the Atmospheric Sciences BS offer significant double counts between the required prerequisites and the GEC, in the areas of Quantitative and Logical Skills, Natural Science Breadth, and Additional Breadth.
Geography Major Revision Summary for CCI

Table of Contents:
1) Summary of Motions for CCI (on this page; below)
2) Gene Mumy (Sciences CCI Chair) Cover Letter
3) Becky Mansfield (Geography Undergrad Studies Chair) Cover Letter
4) BS- Geographic Information Science Proposal
5) BS- Atmospheric Sciences Proposal
6) BS/BA- Geography Tracks Proposal
7) Concurrences and letters of support
8) Transmittal history
9) School of Earth Sciences/Department of Geography correspondence

Summary of Motions for CCI to act upon

1. New Bachelor of Science in Geographic Information Science
2. New Bachelor of Science in Atmospheric Sciences

Geography Major - 4 revised tracks

3. Revised Bachelor of Science in Spatial Analysis
4. Revised Bachelor of Science in Climatology and Physical Geography
5. Revised Bachelor of Arts in Urban, Regional, and Global Studies

Revised Bachelor of Arts in Environment and Society:

6. Approval of curricular changes
7. Approval of track name change
May 22, 2009

From January 26, 2009 to April 7, 2009 the CCI Sciences Subcommittee spent a considerable amount of time evaluating a package of proposals to alter specializations in the Geography major and establish two new majors in the areas of Atmospheric Sciences and Geographical Information Science. The current Geography major requires students to complete at least one of four specialization areas. The proposed revisions to the Geography major include name changes for all of the specializations and at least some changes to the content of all of the specializations. The proposed revisions to two of the specializations are linked to the creation of the two new majors. Issues concerning the specializations will be considered first and then those concerning the new majors.

I. Urban and Regional Studies (a BA specialization)

   A. Change Name to Urban, Regional, and Global Studies

      Rationale is that the new name better reflects the levels of scale and integration required for appropriate analysis. The addition of global also reflects faculty research and teaching strengths, which is reflected in course content and design.

   B. Repackage requirements and add new courses.

      The repackaging presents a more coherent path through the specialization and aligns requirements and electives with current pedagogical practice in the discipline. A new Human Geography course (205) provides a basic foundation; a new capstone course, Geographic Inquiry (600), gives historical perspective to the specialization; and a Research and Professionalization Seminar (695) develops applications of specialization content. The three new courses add 15 credit hours to the Specialization, which is partially offset by eliminating a methods requirement and a physical Geography course.

      **The revised specialization has 55 credit hours, which is 5 more than in the current specialization**

II. People, Society, and Environment (a BA specialization)

   A. Change name to Environment and Society.

      Rationale is that Environment-Society Relations has been a core area of Geography since its inception as a discipline, and the new name better identifies this content to students than the somewhat cumbersome current name. The proposed new name has also become a disciplinary norm.
B. Restructure the required areas in the specialization and replace some current courses with geography courses that have been developed recently.

Because of the specific expertise of new faculty and changing faculty interests in general, there are now many courses in Geography that can usefully be separated into Physical Geography (the environment side) and Human Geography (the society side) and packaged as such to provide a particularly geographical perspective on Environment and Society. Therefore it seems useful to package courses into these two areas along with a Methods requirement.

There is some concern about eliminating all non-geography courses in the specialization. However, analysis of outside-geography enrollments of students in the specialization since its inception in 2002 has been very small. The most taken outside course has been EEOB 413.01, which has averaged three of these students a year (see appendix L).

Because of variation in course credit hours the current specialization requires 50-60 credit hours and the proposed revised specialization standardizes credit hours at 55.

Revisions to the two BS specializations in the Geography major are linked to proposals to create two new majors in Atmospheric Sciences (AS) and Geographical Information Science (GIS). Some of the content of the new majors will be withdrawn from or altered in the setup of the Geography specializations.

III. Analytical Cartography and Geographical Information Systems (BS specialization)

A. Becomes Spatial Analysis

The revised specialization is meant to provide a general geography education along with technical expertise in spatial analysis. The revised specialization should be attractive to students thinking of pursuing graduate education in Geography and related fields, or professional careers requiring the use and planning for spatial data. By way of contrast, GIS is focused on technical expertise in spatial data management, analysis, and visualization. The specialization name reflects its distinctness from GIS.

B. Curriculum Revision

The proposed curriculum revision gets rid of the rigid GIS and Analytical Cartography sub specializations but keeps some content of both content in its own core and much more of both as possible electives. So while gaining some core knowledge, the revised curriculum is much more flexible in allowing a student choice in particular additions to technical expertise and applications. This additional flexibility is also a feature of the proposed new major in GIS, which raised one issue.

Under the proposed curricula for the two majors, it would be possible to satisfy the requirements of both with only a one course difference, raising the question of how are the two degrees distinct. Geography’s position is that this possibility arises only because
of a desire not to limit areas of additional expertise or application in either degree, but most emphasis in Spatial Analysis electives would differ from emphasized areas in GIS electives because of what students in each are trying to achieve. So, it would be very rare for course work in the two majors to vary by only one course. The subcommittee found this explanation to be convincing.

**Credit Hours increase from 44/45 to 50**

**If approved, implementation of the revision is contingent on approval of the proposed GIS major (see below)**

IV. Atmospheric and Climatic Studies

A. Becomes Climatology and Physical Geography

This name reflects now mainstream recognition of the interconnection between the Earth’s surface and the atmosphere and provides the connection between climatology and physical geography. Deeper analysis of atmospheric phenomena is moved to the proposed AS major. Coupling existing strengths in climatology with physical geography also provides a coherent platform for undergraduate teaching by new faculty with specialties in or related to physical geography, e.g. in biogeography and hydrology.

B. Curriculum Revision

The specialization is designed to provide *general geographic education* alongside *technical expertise in climate and physical geography*. Students in this specialization will be introduced to a broader array of methods and applications courses from which they will be able to select. Further, a specialization with emphasis on broad physical geography education is more common in the discipline than the current specialization, which focuses almost exclusively on atmospheric sciences.

The new curriculum includes two different paths, in Climatic Studies (CS) and in Physical Geography (PG). These paths reflect both student demand and current faculty expertise. Each path has math, physics, and statistics prerequisites (30 hours for CS, 20 for PG), distinctive core requirements (28-30 for both paths), and electives (25 hours for both paths), which allow considerable exploration into the other path.

**Prerequisite credit hours for CS have increased by 5. Compared to the current CS path, core requirement and elective credit hours in both revised paths have increase from 43 to 53-55.**

**If approved, implementation of the revision is contingent on approval of the proposed AS major (see below)**
OVERALL APPRAISAL OF GEOGRAPHY MAJOR REVISION

The Sciences Subcommittee recognized that a tremendous amount of thought and work went into the revisions. Some relatively minor changes were made during the process and the committee was more than satisfied with the content of the specialization changes. With the exception of the proposed change to Environment and Society, the name changes were uncontroversial. The proposal also contained an appropriate description of learning outcomes and assessment plan. As a result, the proposed names and curricular content of the following specializations were each **Unanimously Approved**:

- Urban, Regional, and Global Studies
- Spatial Analysis
- Climatology and Physical Geography

Because of some unresolved concerns of Earth Sciences about the name of the Environment and Society specialization (now resolved), the subcommittee voted separately on the curricular content of the revision and the name change.

- Curricular revision -- **Unanimously Approved**
- Name change -- **Unanimously Approved**

At this point the name change and curricular content of this specialization can be treated as a single item.

THE PROPOSED NEW MAJORS

The proposals to create BS majors in GIS and AS have already been on in relation to revisions of the Geography major specializations in which they now exist. Coherent programs in these two areas are being lifted out of the current specializations in order to allow stand-alone development and to create distinctive and clearly identifiable majors in these areas.

I. The proposed GIS major (BS)

A. Rationale

1. There is extensive and growing demand for GIS skills (managing, analyzing, and communicating geospatial information) and the highly-ranked Geography Department has world class expertise in the area.

2. A common set of expertise and skills for being a GIS professional is crystallizing and it requires more breadth and depth than is easily achieved as a track in a geography major.

3. Students looking for essentially a professional degree generating these skills and expertise have difficulty identifying programs that produce them. The new degree
will identify the existence of exactly this kind of program in a highly ranked geography department.

4. Employers looking for people with GIS training can clearly identify a GIS major in a transcript.

B. Proposed Curriculum.

The proposed curriculum is grounded in the GIS path of the current Analytical Cartography and GIS specialization. The required prerequisites are essentially unchanged (10 hours) but additional breadth and depth (more sharply focused) are apparent in the proposed core requirements and electives. The proposed core contains two more courses (for 45 hours) than the current core: this is accomplished by moving the choice of one of two CSE courses to a more focused electives list, while adding two newly developed courses and requiring both of what is currently a choice of one out of two courses. The number of electives does not change (2 courses) but the choice set in the proposal is a list of specific courses as opposed to, e.g., the current requirement that one elective be any human geography course at the 600 level.

**Credit hours in the proposed major are 53-55, as compared to 43-45 in the current specialization path (there are 10 credit hours of prerequisites in both).**

C. Assessment plan.

There are well specified goals for the major and an appropriate assessment plan based on the assessment plan for the Geography major.

**OVERALL APPRAISAL**

The subcommittee found the rationale to be compelling and the proposed curriculum appropriate to the rationale and **Unanimously Approved** the proposed GIS major

II. The proposed AS major (BS)

A. Rationale

1. The Geography Department is the home of strong Ph.D. program is AS with the required faculty expertise and facilities to offer full menu of degrees in AS

2. Although no university in Ohio currently offers a BS degree in AS, several peer institutions with strong Ph.D. programs do.

3. Undergraduate students have indicated a desire to have a major that accurately identifies their interests.
4. The distinct major designation helps employers identify qualified job candidates.

5. A stand-alone AS major is easier to tailor to the standards of the American Meteorological Society’s Policy Statement on *Bachelor’s Degree in Atmospheric Science*.

**B. Proposed Curriculum**

As compared to the current AS specialization path, the proposed major adds 10 additional hours of science preparation with an additional physics course and a general chemistry course, bringing total prerequisite credit hours to 50, 35 of which can overlap with the BS GEC. The proposed core requirements are identical to the current AS path core requirements (43 hours). The current AS path has no electives requirement but the proposed major gives some flexibility in acquiring additional depth or application breadth by requiring two elective courses from a limited list. The proposed curriculum seems to provide substantial math and science preparation for a focused set of major courses, which clearly satisfies professional standards for an AS Bachelor’s degree.

**C. Assessment plan.**

There are well specified goals for the major and an appropriate assessment plan based on the assessment plan for the Geography major.

**OVERALL APPRAISAL**

The subcommittee found the rationale to be compelling and the proposed curriculum appropriate to the rationale and **Unanimously Approved** the proposed AS major...

Respectfully Submitted,

Gene E. Mumy  
Chair (at the time of approval)  
CCI Sciences Subcommittee
30 September 2008

Dr. Kate Hallihan
ASC Curriculum and Assessment Office
4132 Smith Lab
174 W. 17th Ave
Columbus, OH 43210

Dear Kate,

The Department of Geography recently undertook a comprehensive evaluation of our entire undergraduate curriculum. Drawing on outcomes of our assessment activities, discussions during faculty meetings, and work by ad-hoc faculty committees, the Undergraduate Studies Committee has put together a proposal to overhaul the existing Geography major. Additionally, we are proposing two new majors to be housed within the department: Geographic Information Science and Atmospheric Sciences. We designed these majors following standards of excellence provided by academic and industry bodies in these fields.

Our proposal is designed with three central goals in mind. The first is to update our curriculum in light of changes in the discipline and in the composition of our faculty. Secondly, the revised curriculum will better prepare our students while providing them more flexibility. Third, these revisions will attract new students to the department, college, and University.

The proposal is packaged as five separate documents:

1. A set of proposals for five new courses, including one GEC course.
2. A set of course change requests for 23 courses.
3. A proposal to revise the existing Geography major. This proposal maintains the four specializations within the major (two of which lead to a BA, and two to a BS). We propose substantial revisions to the curriculum for each of the four specializations, each of which is structured very differently.
4. A proposal for a new Bachelor of Science in Geographic Information Science
5. A proposal for a new Bachelor of Science in Atmospheric Sciences

We look forward to working with the Curriculum Office this year to improve these proposals and see them through the approval process. We are confident that the proposals will lead to a much stronger and more attractive Department of Geography at Ohio State.

Sincerely,
Becky Mansfield
Chair, Undergraduate Studies
mansfield.32@osu.edu
247-7264
Proposal: Bachelor of Science in Geographic Information Science

I. GENERAL INFORMATION

1. Give the name of the proposed major.
Geographic Information Science

2. State what degree students competing the major will receive.
Bachelor of Science in Geographic Information Science

3. State the proposed implementation date.
Autumn 2009

4. Identify the academic units (e.g. department, college, etc.) responsible for administrating the major program.
Department of Geography, College of Social and Behavioral Sciences, Colleges of the Arts and Sciences

II. RATIONALE

5. Describe the rational/purpose of the major.
Maps have long served as a means for presenting location-based information. However, since the advent of computerized geographic information systems (GIS) in the 1960s, as well as the subsequent development of software and computing power, maps have become a much more widespread means for managing, analyzing, and communicating geospatial information.

The extensive demand for GIS skills has entailed a significant role for Geography. Indeed, although GIS is a multi-disciplinary endeavor, geographers have produced the bulk of what now comprise the core knowledge areas of the field. The Geography department at Ohio State in particular has been at the forefront of developments in GIS over the past 40 years. The department is ranked in the top 5 departments nationally, and is recognized globally as a leader in cartographic, spatial analytic and GIS-related teaching and research.

There are currently two GIS-related specializations offered in the department: Analytical Cartography and Geographic Information Systems (See Appendix B). These specializations reflect a division of labor between faculty in the department dating back several decades. Due to a significant turnover in faculty appointments over the past decade, as well as to changing pedagogical norms, we currently offer only the GIS specialization. The GIS specialization is popular among students: we enroll on average about 40 students per year, representing approximately 20% of our departmental majors.

Our department’s commitment to revising the GIS curriculum dates to the late 1990s. In 1998, Professor Duane Marble (now emeritus), was appointed chair of the national Model Curricula Task Force commissioned by the University Consortium for Geographic Information Science (UCGIS). The UCGIS task force was convened in order to address worries by GIS departments across the country that undergraduate curricula in GIS were dated, and that as a result
students were inadequately prepared for the demands of the workplace. The task force deliberations were recently published as the *Geographic Information Science and Technology Body of Knowledge 2006* (DiBiase et al., 2006). The report reflects the insights of more than 70 educators, researchers, and practitioners. Its goals are to a) foster greater coherence and effectiveness within the GIS education community, and b) to outline what core knowledge, skills, and applications areas should be covered in a rigorous geographic information science education (see Appendix A).

During the 2007-2008 academic year, GIS-related faculty in the department undertook an extensive and collaborative review of course content based on the external standards of excellence suggested in the 2006 report. We also solicited detailed feedback from current geography majors specializing in GIS. Our goal was to identify significant overlaps and/or shortcomings in our curriculum. Our review indicated that while we cover a significant amount of the material suggested in the 2006 UCGIS document, our curriculum could do more to cover some fundamental knowledge areas. Faculty and students also agreed that while students are generally well-prepared for post-graduation employment, more could be done to enhance our graduates' readiness for the job market, including ensuring enough depth and breadth of coursework in the core areas of GIScience and emphasizing application oriented training.

Based on the importance of geotechnologies in society, the strength of the Department of Geography at OSU, the existence of the Body of Knowledge 2006 document, and the recent review by the department, the department is proposing a new major in Geographic Information Sciences (Appendix C). There are three main rationales for proposing a new major:

1. The new major will allow students to gain unprecedented breadth and depth in GIS. Students in the proposed major will receive comprehensive and progressive training from the top scholars in the field. Students not only learn to use software, but also the underlying theories for data structures, geographic analysis, as well as its application to a variety of real world issues. The comprehensive nature of this training not only exceeds that offered by GIS certification programs (which mainly focus on learning software), but also that offered in the current GIS specialization in the OSU Department of Geography.

2. The new major will benefit not only from the expertise of current faculty, but from the long history of research, teaching, and application of GIS in the OSU Department of Geography. Students in this major will profit from the depth of experience this department has in research and teaching on geotechnologies.

3. The major will increase the visibility of GIS at the Ohio State University and in the State of Ohio. Although geospatial technology is among the most important emerging fields today (Gewin 2004), it is not as visible as it should be. This seems to be because GIS is embedded in the discipline of geography, which is unfamiliar to most undergraduates in the United States. Having a stand-alone major will help overcome this problem; at the same time, having that major associated with a top-ranked geography department will ensure that the major continue to benefit from its disciplinary home.
6. Identify any unique characteristics or resources that make it particularly appropriate for Ohio State to offer the proposed major.

A. Department resources.

The proposed major will continue to be housed in Geography, where it will benefit from the department’s world-class faculty and depth of experience in GIS education. The major also benefits because the courses and facilities are not only in place, but already well-tested.

Faculty: The department of Geography has seven full-time tenure track faculty in the area of GIS and related sciences (out of a full faculty of 25) (see Appendix F and Appendix G). These leaders in the field are internationally known for their innovative research. Many have ongoing collaborations and formal affiliations with other departments and colleges on campus, which will broaden the resources available to students in the proposed major.

Teaching resources: The department already offers almost all courses that are required in the proposed major. Included among these is an interdisciplinary course in the Fundamentals of GIS (Geog 607) that is co-taught by faculty in Geography, Civil Engineering, City and Regional Planning, and Geodetic Science.

Computer facilities: The department has extensive computer labs with necessary software and instrumentation for teaching and research in the many aspects of GIScience. See Section 30 for a full description.

Student space and facilities: The department also has an active Geography Club, in which GIS majors will be encouraged to participate; this Club will soon have its own academic resource center with computer facilities, academic journals, and publications of current faculty.

Advising staff: The department maintains its own undergraduate advising program, that will also serve the students in the GIS major. Rick McClish is the fulltime undergraduate advisor, and Assoc. Prof. Becky Mansfield serves as the honors advisor.

Relations with local government and business: Through ongoing research projects, alumni, and an active internship program, geography has existing linkages with a variety of state and local government agencies (e.g. Ohio EPA) and local businesses (e.g. Nationwide Insurance). These linkages are especially valuable for students seeking internship positions. Current Geography students with a GIS specialization have obtained valuable experience through such internships, many of which are paid positions.

B. University resources.

Centers for research and outreach: The university has a variety of centers for interdisciplinary research and outreach that help inform and enhance course content, provide points of contact for students, and provide potential for other forms of interaction beyond the university (e.g. internships, hourly positions, undergraduate research). Primary among these is the Center for Mapping, whose mission focuses on GIS and related technologies. Others include the Center for Human Resource Research, the Criminal Justice Research Center, the Center for Urban and Regional Analysis, John Glenn Institute for Public Service and Public Policy, the Kirwan Institute for Race and Ethnicity, and the Initiative on Population Research.
Library resources: Another important university resource unique to Ohio State is the Libraries Map Room collection, which includes a wide array of map collections of regional and global significance. The libraries has a dedicated librarian for Maps, Steve Rogers, who has many years of experience with the collection and with helping undergraduate students.

7. Cite the benefits for students, the institution, and the region or state.

The primary benefit for students is that the proposed new major is tailored specifically to fit the needs of students who want to pursue careers or higher education in geospatial technologies. Students will develop a substantive knowledge base that answers to specific job market demands in a growing industry. It also clearly identifies the students’ major as Geographic Information Sciences, which is a degree that is clearly recognized by potential employers. A bachelor’s degree in GIS is today the preferred entry level degree for a beginning career as a GIS professional (see item 10 below). The proposed major is organized to provide the foundation and skills necessary with a clear path to graduation. It also includes sufficient flexibility that the professional undergraduate advisor in Geography can help students choose the courses to satisfy the requirements of the General Education Curriculum (GEC) and their electives to match their specific goals. Students who complete the proposed major will be well positioned to take the next step after they graduate.

The principal benefit to the university is that the proposed new major will attract some high quality students that would otherwise attend other universities. Having a prominent GIS major will attract driven and goal-oriented students from across Ohio, and beyond. In addition to adding to the intellectual vitality of the university, some of the best students may also choose to continue at Ohio State and do their graduate work in the Geography department. Another benefit of the proposed major to the University is that it will provide the opportunity for students in other majors to double-major or minor in GIS. This will provide these students with both substantive knowledge and technical skills that will enhance their position in the job market. A GIS major will also make an important contribution to the University’s outreach mission by means of the many application and service learning-oriented courses in the curriculum. Several courses require students to engage directly with clients, both within and outside of the university, in various forms of projects ranging from spatial database development, to integrated spatial analyses, to map design.

The principal benefit to the state of Ohio is that the proposed new major would keep more bright motivated undergraduate students in the state, as there are currently few universities in Ohio that currently offer an undergraduate major in GIS. The proposed new major would also provide a source of potential employees for the wide range of businesses that require people who can manipulate, analyze, and visualize spatial data. Major employers such as Nationwide Insurance, American Electric Power, city and regional governments all need employees with expertise in designing and using GIS.
8. List similar majors offered in both public and private institutions in Ohio and the U.S. Explain how these majors compare to the one proposed.

Valid data on GIS oriented degrees are difficult to obtain since the field does not have an unambiguous Classification by Instructional Program (CIP) code in the U.S. Department of Education data bases. It is clear, however, that very few higher education institutions offer baccalaureate degree programs in GIS. Many offer specializations in GIS as part of a degree in geography, which is the current situation here at Ohio State. While these provide intermediate and advanced training in GIS, they do not offer the comprehensive and progressive training of the proposed BS in GIS.

Within Ohio, only one other university (Ohio University) offers a four-year major in GIS. As with the current proposal, this major is housed in a Geography department. However, unlike our proposed major, students at Ohio University complete the requirements for a general Geography major rather than focusing extensively on GIS related knowledge and skills. Six universities and colleges offer a GIS certificate program and/or a 2-year degree, one offers only a GIS minor, and three (other than OSU) offer GIS as a specialization within the Geography major.

**GIS Education in Ohio**

<table>
<thead>
<tr>
<th>Bowling Green State University</th>
<th>Bowling Green, OH</th>
<th>Geography &amp; Geology major</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleveland State University</td>
<td>Cleveland, OH</td>
<td>Graduate and undergraduate GIS certificate programs</td>
</tr>
<tr>
<td>Columbus State Community College</td>
<td>Columbus, OH</td>
<td>GIS Certificate and 2-yr degree programs</td>
</tr>
<tr>
<td>Hocking College</td>
<td>Nelsonville, OH</td>
<td>GI/GPS Certificate and 2-year degree program</td>
</tr>
<tr>
<td>James A. Rhodes State College</td>
<td>Lima, OH</td>
<td>GIS Certificate and 2-year degree program</td>
</tr>
<tr>
<td>Kent State University</td>
<td>Kent, OH</td>
<td>Geography major</td>
</tr>
<tr>
<td>Miami University</td>
<td>Oxford, OH</td>
<td>GIS Certificate</td>
</tr>
<tr>
<td>Ohio Northern University</td>
<td>Ada, OH</td>
<td>GIS minor</td>
</tr>
<tr>
<td>Ohio State University</td>
<td>Columbus, OH</td>
<td>Geography major</td>
</tr>
<tr>
<td>Ohio University</td>
<td>Athens, OH</td>
<td>GIS Analyst major</td>
</tr>
<tr>
<td>Ohio Wesleyan University</td>
<td>Delaware, OH</td>
<td>Geography major</td>
</tr>
<tr>
<td>University of Cincinnati</td>
<td>Cincinnati, OH</td>
<td>BS Geography</td>
</tr>
<tr>
<td>University of Akron</td>
<td>Akron, OH</td>
<td>BS Geography and Certificate in GISCi</td>
</tr>
</tbody>
</table>
9. Cite enrollment patterns of similar majors in Ohio or in the United States.

We conducted a survey of GIS programs at four-year institutions in Ohio, and other university of similar size, including peer Big 10 institutions. Of these contacts, we received a few responses.

Departments with GIS majors: Ohio University currently has 18 students enrolled in the GIS major, with yearly enrollments averaging between 15-20 students since inception of the program seven years ago. Michigan State University has had on average 12 students since the major’s inception in 2005. (Their specialization averages 20 students per year).

Departments with GIS specializations within the Geography major: University of Cincinnati has a modest number of students in the GIS specialization of the Geography major (3-4 students per year). University of Minnesota has a specialization in GIS, with about 27 students per year. The department just began a minor in GIS, to begin Fall 2008.

10. Describe career opportunities and/or opportunities for graduate or professional study available to persons who complete the major.

Students graduating from OSU with a major in GIS will be well positioned to find gainful employment. In 2004 the U.S. Department of Labor identified geotechnology as one of the three most important emerging and evolving fields, along with nanotechnology and biotechnology. Traditionally, the public sector has been the main employer of GIS professionals. There are also growing opportunities within the private sector. An informal study of current jobs listed on the website “gisjobs.com” included positions with the federal government (USEPA, USDA), state and local government (city, county), industry (e.g., software companies, consulting firms, location-based service providers), and academia (providing research support to interdisciplinary centers). Within these current employment opportunities, applications include resource management, spatial database development and management, environmental planning, transportation planning, software development, cartography, conservation, urban planning, and spatial decision support services.

Graduates of the proposed GIS major will be well-prepared for positions beyond routine use of geospatial technologies, and able to apply spatial analysis techniques to address sophisticated problems in a variety of fields. In addition, graduates of the proposed program will have begun to develop the business and communication competencies required for advancement in government agencies and private businesses.

Graduates of the proposed GIS major will also be very competitive for continued academic study, at OSU or other universities. Current trends in the discipline (as evidenced the “Jobs in Geography” website maintained by the Association of American Geographers [AAG]) are that graduates of doctoral programs in geography and cognate disciplines with GIS skills, expertise, and research interests are highly in demand.
11. Describe any licensure or certification for which this major will prepare students.

Given the relatively short history of GIS, certification of GIS programs is still a new phenomenon. The UCGIS Body of Knowledge (DiBiase et al. 2006) has clearly defined core competencies, which are the basis for a new certification system for GIS professionals by the GIS Certification Institute. This certification includes three components: educational achievement, professional experience, and contribution to the profession. Students in the new GIS major will be able to document and complete the educational attainment component of a GIS professional certificate.

III. GOALS/OBJECTIVES/EVALUATION

12. Provide a learning outcomes assessment plan for the major program.

A. State the general and specific educational goals and objectives for the major.

The general educational goals for the major are that students will:

1. learn how to operationalize fundamental concepts in Geographic Information Sciences.
2. achieve proficiency with methods of Geographic Information Sciences.
3. be provided with a strong foundation for seeking employment or graduate or professional training.

The specific educational goals for the major are:

1. **Technical**: Students will acquire an ability to assess relationships among geospatial technologies, GIS theory and applications, technical writing, and technological literacy.

2. **Analytical**: Students will become creative thinkers, acquire problem-solving skills, and demonstrate an ability to situate GIScience in a larger societal context.

3. **Communication**: Students will be able to represent complex technical information orally, visually, and in writing.

B. Indicate the methods that will be used to assess whether the educational goals and learning objectives are being met.

The Department of Geography currently has an assessment plan that includes a suite of outcome monitoring methods that allows us to gauge whether or not we are meeting pedagogical goals and to make necessary corrections. The plan is reviewed annually by the College of Social and Behavioral Sciences, and is overseen by our undergraduate advisor. The current plan consists of two indirect assessment methods and one direct method. Geography's assessment methods include:

- Embedded questions in one regularly offered and popular upper division course
- Informal focus groups with students in the major. In the 2007-2008 school year we conducted four such groups, one for each specialization.
- An exit survey of graduating seniors, which includes questions about the major regarding overall educational experience, classroom experience, research and internship participation, and placement in jobs and graduate school.
As part of the proposed overhaul of the Geography major, we have engineered an improved assessment strategy. As we gain experience with assessment and as the needs of the department change, we will refine our methods of assessment. We expect the result to be geography majors who are better prepared for graduate studies and the job market. Our plan includes continued use of focus groups and exit surveys with graduating seniors. We also include expanded use of embedded testing to reach 100% of our undergraduate majors.

Because the proposed GIS major will remain within the department of Geography, assessment for the GIS major will use the same techniques as assessment of the Geography major. We will include focus groups, exit surveys, and embedded testing techniques. Embedded testing will take place in the GIS Applications in Social Science and Business (686), and GIS Design and Implementation (687) courses. These classes are ideal for embedded testing because they not only teach methods and skills, but require students to express their general knowledge about concepts and methods in GIS and integrate these skills in an applied project. A group of faculty who specialize in GIS is currently developing a set of embedded questions for this class that will assess the department’s success in teaching students technical, analytic, and communication skills.

C. Provide the time over which the assessment plan will be implemented.

Because the GIS major will remain within the Department of Geography, the above plan will be implemented immediately. We will continue to revisit our assessment methods, deciding which methods and techniques yield the most useful information. We currently produce an annual assessment report for the College of Social and Behavioral Sciences. For the new major, in Year 4 we will do an extensive additional report which looks at the educational experience of our first full cohort of GIS majors.

D. Describe how outcomes information will be used to improve student learning and program effectiveness.

1. The Undergraduate Studies Committee, in consultation with the undergraduate advisor, will review annual assessment data for GIS majors. These data will be used to make suggestions to faculty regarding content and pedagogical practice for existing courses in the GIS major.

2. The Undergraduate Studies Committee and the undergraduate advisor, along with an advisory committee of GIS-related faculty, will convene at the end of the third year to design a special assessment mechanism for the first graduating cohort. The group will meet again at the end of the fourth year to collate and analyze the data. These results will be used to consider more substantive changes of the GIS curriculum, including suggestions for any necessary new courses, course sequencing, and professionalization experiences such as internships and undergraduate research.
IV. RELATIONSHIP TO OTHER PROGRAMS

13. Describe current major and minor programs in the department(s) and how they relate to the proposed major.

Currently the Department of Geography offers BA and BS degrees in Geography, as well as a minor in Geography. A proposal for revision of the major is currently under review; the description here is of the current structure, with indication of important changes we are proposing.

Students majoring in geography choose one of four specializations: Analytical Cartography/Geographic Information Systems (BS), Urban and Regional Studies (BA), People-Society-Environment (BA), and Atmospheric and Climatic Studies (BS). These divisions represent long-standing core areas of knowledge in the geography discipline, and are mirrored at many of our peer institutions. The four specializations have unique, though overlapping, curricula that convey core geographical concepts and methods while allowing students to develop expertise in a particular area. The proposed structure retains these four tracks, renames them, and changes some of the requirements in them. Like the major, the minor in Geography has the same four specializations. Students are required to take five courses from a list of courses specific to each specialization.

As discussed in point 6, above, the proposed major in GIS relies extensively on the resources and structure of the Geography department. The courses for the new major already exist in the Geography department, current Geography professors comprise the faculty, and the department has a variety of resources (e.g. computer facilities) that will be available to students in the proposed major.

Approval of the current proposal for a major in GIS will allow for a separation of GIS training into two complementary levels. Within the geography major, the current Analytical Cartography/Geographic Information Systems specialization will become "Spatial Analysis" and will focus on geographical analysis methods in broader terms and provide a more general geographic education. (This Spatial Analysis specialization would be similar to the GIS major offered at Ohio University, which requires students to fulfill the requirements of the Geography major.) The proposed GIS major at OSU will provide full coverage of core knowledge areas in the GISciences, training students to become highly trained experts in their fields. We designed the two programs to attract and train different types of students. Students in the GIS major will be trained for professional careers specializing in spatial data, prepared to fill roles related to data acquisition and management, application development, training, data analysis, interpretation, and visualization. Students choosing the Spatial Analysis specialization will be prepared either for graduate school in Geography, or for careers that require them to use and plan for spatial information, for example in roles related to project management, systems analysis, coordination, training, and marketing. There is substantial overlap in the courses available to students in the two programs, which serves two purposes. First, students in both programs need to achieve adequate technical proficiency. Second, we want to provide maximum flexibility for students to design their programs around their specific interests and career paths. All students will be encouraged to design courses of study that take full advantage of the range of courses available.
An additional advantage of offering a GIS major is that it will allow students to pursue double majors. The GIS profession is highly interdisciplinary, as geospatial information is increasingly becoming a driving force for decision making across the local to global continuum. The GIS degree will likely be a popular complement to a degree in Geography, with focus in one of the other, substantive areas of specialization. This will allow students to combine sophisticated technical knowledge with in-depth knowledge in a substantive area (e.g. environmental issues, urban planning). The GIS degree will also be a popular complement to degrees in, inter alia, landscape architecture, city and regional and planning, computer science, natural resources, political science, and business. In addition many seeking a complement to their major will also benefit from a minor in GIS that will provide students with a general knowledge of geographical analysis methods.

14. Identify any overlaps with other programs or departments within the University. Append letters of concurrence or objection from related units.

<table>
<thead>
<tr>
<th>Geodetic Science</th>
<th>603 Remote Sensing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>607 Fundamentals of Geographic Information Systems</td>
</tr>
<tr>
<td></td>
<td>640 Decision-Making with GIS</td>
</tr>
<tr>
<td></td>
<td>774 Spectral Methods and Raster Geometry in Digital Mapping</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>608 Spatial Analysis Techniques in Civil Engineering</td>
</tr>
<tr>
<td>City and Regional Planning</td>
<td>608 geographic Information Systems in Professional Planning Practice</td>
</tr>
<tr>
<td>Environment and Natural Resources</td>
<td>324 Natural Resources Photointerpretation</td>
</tr>
</tbody>
</table>

Concurrence letters are attached in Appendix D.

15. Indicate any cooperative arrangements with others institutions and organizations that will be used to offer this major.

None

16. Specify any articulation arrangements (direct transfer opportunities) with other institutions that will be in effect for the major.

None
17. Provide information on the use of consultants or advisory committees in the development of the major. Describe any continuing consultation.

This proposed major was developed by the Undergraduate Studies Committee, chaired by Professor Becky Mansfield, in consultation with an ad-hoc committee within the current Analytic Cartography/GIS specialization, headed up by Professor Ola Ahlqvist. Our evaluation of the specializations was inaugurated in W107, with recommendations brought before the faculty in SP08. Faculty support for the changes was unanimous.

18. Indicate whether this major or a similar major was submitted for approval previously.

Neither this nor a similar major has been submitted previously.

19. Indicate where students will be drawn from, e.g. existing academic programs, outside of the University, etc. Estimate the mix of students entering the major internally and externally

Although it is extremely difficult to predict enrollment in our proposed GIS major, based on our current enrollment of approximately 35 majors per year in the GIS specialization, we estimate that the number of students enrolled in the GIS major will double by year four (see question 20, below).

**Internal transfers:** Our proposed major in GIS will, for the most part, draw students from the Geography major (current specialization in GIS). We are currently conducting a survey with our Geography majors as well as alumni in the GIS specialization, gauging their interest/opinion of a GIS major. At this point we expect most if not all of our current GIS students to transfer in the event that the GIS major is approved.

**External entry:** We expect that the new GIS major will attract a significant number of new students to OSU, both regionally and nationally. Faculty affiliated with the proposed GIS major will lead a major national-scale recruitment drive in the event that the major is approved. Given the high visibility of our faculty, we expect to draw a significant amount of interest.

**Double major/minor:** Given the multi-disciplinary nature of GIS it is likely that some students see the value of a double major or a minor in GIS as a way to augment their job placement or graduate studies opportunities.

**Student mix:** We anticipate very little disturbance to existing programs at OSU due to our proposed GIS major. Although some students will change to the GIS major from others such as Civil Engineering or Computer Sciences, we also expect that most new majors will be incoming freshman.
V. STUDENT ENROLLMENT

20. Indicate the number of students you anticipate will be admitted to the major each year.

<table>
<thead>
<tr>
<th>Regular Academic Year</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full-time (new entering)</td>
<td>35</td>
<td>8</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Full-time (cumulative)</td>
<td>35</td>
<td>43</td>
<td>53</td>
<td>65</td>
</tr>
<tr>
<td>Part-time (new entering)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Part-time (cumulative)</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Estimated Summer Enrollments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Part-time</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Our estimated enrollment in full-time studies during the first four regular academic years is based on current enrollment figures for the GIS specialization in Geography. Since AU03 we have averaged 35 new majors per year in the GIS specialization.

VI. REQUIREMENTS

21. List the courses (Department, title, credit hours, description) which constitute the requirements and other components of the major. Indicate which courses are currently offered and which will be new. Append a quarter-by-quarter sample program and all New Course, Course Change, and Course Withdrawal forms necessitated by the implementation of the proposed major.

There are three components to the proposed GIS major: required prerequisites or supplements to the major, core requirements, and electives. (See Appendix C for schematic version and Appendix H for course syllabi)

The 9 hours of required prerequisites and supplements to the major include a choice of introductory computer programming classes (CSE 201 or 202), and Introduction to Statistical Analysis (STAT 245). These courses provide a computing and mathematical basis for further training in the major and are also in line with OSU requirements for a BS degree.

The core requirements component of the major consists of 45 credit hours, representing depth and breadth in the major subfields of GIS. The GIS sequence including Fundamentals of Geographic Information Systems (607), Intermediate GIS (685), GIS Applications in Social Science and Business (686), and GIS Design and Implementation (687). A sequence in the
subfield of cartography and geovisualization includes Map Reading and Interpretation (480), Elements of Cartography (580) and Computer Cartography and Geographical Visualization (680). These sequences in GIS and cartography are rounded out by the course Quantitative Geographical Methods (683) and Geographic Applications in Remote Sensing (684).

Finally, the third component of the proposed major is 8-10 hours of elective courses across Geography and Computer Science & Engineering. Two courses can be chosen from the following, depending on the student’s interests and career goals: Geography of Transportation (645), Locational Analysis (647), Land Use Geography (655), Emerging Topics in GIS (688), Seminar in GIS (787), Undergraduate Seminar in Research and Professionalization (695), Earth Systems Data Collection and Analysis (Earth Sci 310), Data Structure for Information Systems (CS&E 214), Introduction to C++ Programming (CS&E 230), Object-Oriented Programming for Engineers and Scientists (CS&E 502), and Introduction to Database Systems I (CS&E 670). We note that those students wanting to take CS&E 214 should choose 201 as a prerequisite, while those wanting to take CS&E 230 or 502 should take 202; we also note that 502 is the prerequisite for 670.

22. State the minimum number of credits required for completion of the major.
53

23. State the average number of credits expected for a student at completion of the major.
We expect most students to have 54 major credit hours when they graduate, based on the average number of credits in the elective courses.

24. Give the average number of credits taken per quarter by a typical student. Estimate the average for each year.
The average number of credit hours is 15 per quarter, for a total of 45 per year. Credit hours vary depending on quarters and the time the GIS major is declared. Sample curricula with quarter by quarter credit hour estimates are shown in Appendix E.

25. Give the number of credits students are required to take in other departments.
The major requires 53-55 credit hours in Geography. The core consists of 45 credit hours (nine courses), all in Geography. Students are also required to take 8-10 credit hours (two courses) of electives. The elective list includes five courses from Geography and four from Computer Science & Engineering. All GEC requirements are taken outside Geography; these amount to 80-100 hours (depending on test placement). This leaves 26-46 free elective credit hours, which can be taken both inside and outside Geography.

26. Give the number of credits a typical student might take as electives in other departments.
20-40 credit hours

27. Describe other major requirements in addition to course requirements, e.g., examinations, internships, final projects.
28. Identify from which specialized professional association(s) accreditation will be sought. List any additional resources that will be necessary to gain such accreditation.

No such accreditation currently exists for GIS education.

29. Describe the number and qualifications of full-time and part-time faculty. List current faculty and areas of expertise. Describe the number and type of additional faculty needed.

The Department of Geography currently has 24 full- or part-time tenure track faculty; seven of these are associated with GIS-related fields. For a list of faculty and specializations see Appendix F and Appendix G. We expect to hire one additional faculty member in this area in the 2008-2009 year, to replace a faculty member who recently resigned. Based on current enrollment patterns and projections, we do not expect to hire additional faculty in the next three years. However, we will consider making hires if justified by additional credit hours generated, in line with Social and Behavioral Sciences and OSU’s budget model.

30. Describe existing facilities, equipment, and off-campus field experience and clinical sites to be used. Indicate how the use of these will impact other existing programs.

**Computing requirement and lab space:** GIS is a computer-intensive field, and Geography has significant computer facilities and space at its disposal. Our major undergraduate-only instructional computer lab (DB0140) comprises 50 state-of-the-art workstations, with a full suite of GIS-relevant software. A sampling of the software loaded on all computers includes, but is not limited to: ArcGIS 9.2, ArcView 3.2 w/ 3D, Encarta, spatial statistics software, Geoda 0.95i, Google Earth, Google Sketchup, IDL 5.5.2 Student version, Illustrator, Mapobjects 2, Maptitude, .Net 1.1, Office 2003, PC GIS 3.2, R, SPSS, VB 6.0 as well as VB .NET.

DB0140 is managed by two full-time technical staff as well as a graduate student. The department is confident that our existing staff will be able to manage the increased traffic through our labs as a result of the GIS major.

Currently, on average, DB0140 is used for seven to ten courses per quarter, with peak hours of usage occurring between 9am and 5pm. This means that careful management of the lab will be required in order to accommodate the growth in GIS majors that we are predicting (see section 20). However, we are fully confident that our predicted enrollment numbers for Year 4 can be comfortably accommodated in the department, for the following reasons:

- There is currently little to no usage of DB0140 in the 7:30-9am slot, and no usage after 5pm. Geography is prepared to expand its use of early morning and late afternoon classes in order to adjust to more lab users as a result of the GIS major.

- Currently, utilization rates (i.e. the number of workstations used) in DB0140 seldom exceeds 50%. This means that we can easily accommodate a doubling of students in DB0140 in any given lab slot.
- There is sufficient physical space in DB0140 to expand the number of workstations by up to 30%, depending on demand as well as resources. We are currently updating the lab with 50 new computers. Although as of yet this will not result in any additional workstations in DB0140, we will be rebuilding the existing computers into 25 workstations to be allocated throughout the department as we see fit, including in the lab as required.

- We are currently moving ahead with a new spacious undergraduate resource center. This will be completed by the end of SU08. A portion of the older computers from DB0140 will be installed in the center so as to expand the number of computers available for use outside scheduled lab hours. We expect our future GIS majors to make substantial use of these machines.

- The department is also prepared to develop an additional undergraduate-only instructional lab should we require the space as a result of the proposed GIS major.

Regular classroom space: Of the nine core courses in our proposed GIS major, all have lecture as well as lab components. Approximately 30% of these courses involve simultaneous lectures and labs in DB0140. The other 70% of the classes require rooms for the lecture portion of the class, in addition to lab time and space. The only course which we do not teach exclusively in departmental classrooms is Geog 607, which is shared with Civil Engineering, City and Regional Planning, and Geodetic Science with lectures currently taught in Dreese 113. The rest of our classes are taught in DB1116, DB1080 and DB0155. Due to the ample size of these rooms, as well as departmental flexibility in allocating classroom usage, we foresee no classroom space restrictions based in the proposed GIS major. Additionally, the department regularly teaches courses in Paige Hall.

In sum, we expect little to no impact on other departments in terms of space use as a result of this proposal.

31. Describe additional University resources, including libraries, that will be required for the new major.

None

32. Describe the major as it would appear in the appropriate college bulletin.

The undergraduate Geographic Information Science (GIS) program concerns the nature of geographic information and the many applications of geospatial technologies, such as Geographic Information Systems. These include applications dealing with basic scientific questions as well as practical solutions for the workplace and everyday life activities. The science and technologies surrounding GIS are multi-disciplinary and range from conceptual geographic foundations, spatial data acquisition, modeling, analysis, and visualization, to societal, organizational, and ethical aspects of GIS.

The program is intended to prepare students for careers in the diverse areas of geospatial
applications. Because technology changes so rapidly, the program emphasizes general principles which will serve graduates throughout their careers, while giving students significant exposure and training in state-of-the-art software and technology. By design, students in the new GIS major will also be able to document and complete the educational attainment component of a GIS professional certificate.

Students graduating from OSU with a major in GIS will be well positioned to find gainful employment, both in the public and private sector. Graduates will be well-prepared for positions beyond routine use of geospatial technologies, and able to apply spatial analysis techniques to address sophisticated problems in a variety of fields. In addition, graduates will have begun to develop the business and communication competencies required for advancement in government agencies and private businesses. Graduates will also be very competitive for continued academic study, at OSU or other universities.

Students pursuing a major in geographic information science must complete 53-55 hours of approved courses.

References


Appendix A

UCGIS Geographic Information Science and Technology Body of Knowledge 2006 (DiBiase et al. 2006)

Knowledge areas (underlined) are clusters of knowledge, skills, and applications that span the breadth of GIScience. Units are coherent sets of topics that embody representative concepts, methodologies, and applications, designed as either core (bold face) or elective (normal face).

**Knowledge Area AM, Analytical Methods**
- Unit AM1 Academic and analytical origins
- Unit AM2 Query operations and query languages
- Unit AM3 Geometric measures
- Unit AM4 Basic analytical operations
- Unit AM5 Basic analytical methods
- Unit AM6 Analysis of surfaces
- Unit AM7 Spatial statistics
- Unit AM8 Geostatistics
- Unit AM9 Spatial regression and econometrics
- Unit AM10 Data mining
- Unit AM11 Network analysis
- Unit AM12 Optimization and location-allocation modeling

**Knowledge Area CF, Conceptual Foundations**
- Unit CF1 Philosophical foundations
- Unit CF2 Cognitive and social foundations
- Unit CF3 Domains of geographic information
- Unit CF4 Elements of geographic information
- Unit CF5 Relationships
- Unit CF6 Imperfections in geographic information

**Knowledge Area CV, Cartography and Visualization**
- Unit CV1 History and trends
- Unit CV2 Data considerations
- Unit CV3 Principles of map design
- Unit CV4 Graphic representation techniques
- Unit CV5 Map production
- Unit CV6 Map use and evaluation

**Knowledge Area DA, Design Aspects**
- Unit DA1 The scope of GI & S&T system design
- Unit DA2 Project definition
- Unit DA3 Resource planning
- Unit DA4 Database design
- Unit DA5 Analysis design
- Unit DA6 Application design
- Unit DA7 System implementation

**Knowledge Area DM, Data Modeling**
- Unit DM1 Basic storage and retrieval structures
- Unit DM2 Database management systems
- Unit DM3 Tessellation data models
- Unit DM4 Vector and object data models
- Unit DM5 Modeling 3D, temporal, and uncertain phenomena

**Knowledge Area DN, Data Manipulation**
- Unit DN1 Representation transformation
- Unit DN2 Generalization and aggregation
- Unit DN3 Transaction management of geospatial data

**Knowledge Area GC, Geocomputation**
- Unit GC1 Emergence of geocomputation
- Unit GC2 Computational aspects and neurocomputing
- Unit GC3 Cellular Automata (CA) models
- Unit GC4 Heuristics
- Unit GC5 Genetic algorithms (GA)
- Unit GC6 Agent-based models
- Unit GC7 Simulation modeling
- Unit GC8 Uncertainty
- Unit GC9 Fuzzy sets

**Knowledge Area GD, Geospatial Data**
- Unit GD1 Earth geometry
- Unit GD2 Land partitioning systems
- Unit GD3 Georeferencing systems
- Unit GD4 Datums
- Unit GD5 Map projections
- Unit GD6 Data quality
- Unit GD7 Land surveying and GPS
- Unit GD8 Digitizing
- Unit GD9 Field data collection
- Unit GD10 Aerial imaging and photogrammetry
- Unit GD11 Satellite and shipboard remote sensing
- Unit GD12 Metadata, standards, and infrastructures

**Knowledge Area GS, GI & S&T and Society**
- Unit GS1 Legal aspects
- Unit GS2 Economic aspects
- Unit GS3 Use of geospatial information in the public sector
- Unit GS4 Geospatial information as property
- Unit GS5 Dissemination of geospatial information
- Unit GS6 Ethical aspects of geospatial information and technology
- Unit GS7 Critical GIS

**Knowledge Area OI, Organizational and Institutional Aspects**
- Unit OI1 Origins of GI & S&T
- Unit OI2 Managing the GI system operations and infrastructure
- Unit OI3 Organizational structures and procedures
- Unit OI4 GI & S&T workforce themes
- Unit OI5 Institutional and inter-institutional aspects
- Unit OI6 Coordinating organizations (national and international)
Appendix B

Current Geographic Information Sciences (GIS) Curriculum

Part A. Required Prerequisites or Supplements to the Major (Credits count towards the major)

1. CS&E 201
2. Statistics 245

Part B. Core Requirements

1. Elements of Cartography 580
2. Fundamentals in Geographic Information Systems 607
3. Numerical Cartography 680
4. Introduction to Geographic Analysis 683
5. Intermediate Geographic Information Systems 685
6. GIS in Social Science and Business Research 686 or Design and Implementation of Geographic Information 687
7. CS&E 214 or CS&E 230

Part C. Electives within the Major

1. Choice of human geography course at the 600 level
2. Choice of one physical geography course from:
   - Physical Geography and Environmental Issues 210
   - Climatology 520
   - Integrated Earth Systems: Confronting Global Change 597.02
3. After students have completed 20 hours of coursework in Geography, they are eligible for an internship and receive credit for it through the department.
Appendix C

Proposed Geographic Information Science (GIS) major

Part A. Required Prerequisites or Supplements to the Major. (Do not count toward the 53-55 hour major)

1. CS&E 201 (Elementary Computer Programming; Java is taught) or 202 (Introduction to Programming and Algorithms for Engineers and Scientists; C++ is taught)
2. Statistics 245

Part B. Core Requirements (45 credit hours)

1. Map Reading and Interpretation 480
2. Elements of Cartography 580
3. Fundamentals in Geographic Information Systems 607
4. Computer Cartography and Geographic Visualization 680
5. Quantitative Geographical Methods 683
6. Geographic Applications of Remote Sensing 684
7. Intermediate Geographic Information Systems 685
8. GIS Applications in Social Science and Business 686
9. GIS Design and Implementation 687

Part C. Electives (6-10 credit hours)

1. Choose two of the following courses:
   - Geography of Transportation 645
   - Locational Analysis 647
   - Land Use Geography 655
   - Emerging topics in GIS 688
   - Seminar in GIS 787
   - Undergraduate Research and Professionalization Seminar 695
   - CS&E Data Structures for Information Systems 214 (4 credits)
   - CS&E Introduction to C++ Programming 230 (4 credits)
   - CS&E Object-Oriented Programming for Engineers and Scientists 502 (3 credits)
   - CS&E Introduction to Database Systems I 670 (3 credits)
     - For the above courses, CS&E suggests that students who have taken 201 for their prerequisite take 214, while those who have taken 202 should choose 230 or 502. The prerequisite for 670 is 502.
   - Earth Sci 310 Earth Systems Data Collection and Analysis

2. After students have completed 20 hours of coursework in Geography, they are eligible for an internship and receive credit for it through the department.
Appendix D

Concurrence

We will be attaching concurrence letters as they are received.
Appendix E

Sample 4-year plan for the GIS major (on the next page)
<table>
<thead>
<tr>
<th>Year 1</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>English 110</td>
<td>Math 151</td>
<td>Math 152</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Math 150</td>
<td>First GEC Natural Science course</td>
<td>Second Foreign Language course</td>
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<tr>
<td></td>
<td>Geography 200 or 240 (GEC Social Science course)</td>
<td>First Foreign Language course</td>
<td>Visual/Performing Arts</td>
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<tr>
<td></td>
<td>University Survey course (1hour)</td>
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<td></td>
</tr>
<tr>
<td>Year 2</td>
<td>Autumn</td>
<td>Winter</td>
<td>Spring</td>
<td>Summer</td>
</tr>
<tr>
<td></td>
<td>Geography 480</td>
<td>Geography 580</td>
<td>Geography 607</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CS&amp;E 201</td>
<td>GEC Second Writing course (367's)</td>
<td>Statistics 245</td>
<td></td>
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<tr>
<td></td>
<td>Third GEC Foreign Language</td>
<td>Fourth GEC Foreign Language</td>
<td>First GEC Historical Study course</td>
<td></td>
</tr>
<tr>
<td>Year 3</td>
<td>Autumn</td>
<td>Winter</td>
<td>Spring</td>
<td>Summer</td>
</tr>
<tr>
<td></td>
<td>Geography 683</td>
<td>Geography 680</td>
<td>Geography 686</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Second GEC Historical Study</td>
<td>Geography 685</td>
<td>Third GEC Natural Science course</td>
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<tr>
<td></td>
<td>Second GEC Natural Science</td>
<td>Literature</td>
<td>Minor or General Elective course</td>
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</tr>
<tr>
<td>Year 4</td>
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<td>Spring</td>
<td>Summer</td>
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<tr>
<td></td>
<td>Geography 687</td>
<td>GIS Major Elective</td>
<td>Fourth GEC Natural Science</td>
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<tr>
<td></td>
<td>Geography 684</td>
<td>First Additional Breadth course</td>
<td>GIS Major Elective</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Second GEC Social Science</td>
<td>Second Additional Breadth course</td>
<td>Minor or General Elective course</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix F

**List of GIS Geography Faculty, with Area of Expertise**

<table>
<thead>
<tr>
<th>Name</th>
<th>Area of expertise</th>
<th>Faculty Status</th>
<th>Percent of Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ola Ahlqvist</td>
<td>uncertainty and semantics, visualization, land-use &amp; land-cover change</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Marie Cieri</td>
<td>Qualitative and critical GIS, GIS and society, representation</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Mei-Po Kwan</td>
<td>3-D GIS, qualitative and critical GIS, travel behavior and accessibility</td>
<td>Core Faculty (Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Desheng Liu</td>
<td>spatial statistics, land-use &amp; land-cover change, remote sensing of the environment</td>
<td>Core Faculty (Assistant Professor)</td>
<td>75%</td>
</tr>
<tr>
<td>Darla Munroe</td>
<td>Environmental modeling, urban, regional, and natural resource planning and development, environmental valuation</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Morton O'Kelly</td>
<td>spatial interaction, spatial optimization, service location models</td>
<td>Core Faculty (Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Ningchuan Xiao</td>
<td>geocomputation, information and communication technologies</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
</tbody>
</table>
Appendix G

List of Other Geography Faculty

<table>
<thead>
<tr>
<th>Name</th>
<th>Faculty Status</th>
<th>Percent of Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jason E. Box</td>
<td>Core Faculty (Associate Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>David H. Bromwich</td>
<td>Core Faculty (Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Mathew Coleman</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Kevin R. Cox</td>
<td>Core Faculty (Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Nancy Ettlinger</td>
<td>Core Faculty (Associate Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Jay S. Hobgood</td>
<td>Core Faculty (Associate Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Jialin Lin</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Ed Malecki</td>
<td>Core Faculty (Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Becky Mansfield</td>
<td>Core Faculty (Associate Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Bryan Mark</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Kendra McSweeney</td>
<td>Core Faculty (Associate Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Yuri V. Medvedkov</td>
<td>Core Faculty (Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Ellen Mosley-Thompson</td>
<td>Core Faculty (Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>David Porinchu</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Jeff Rogers</td>
<td>Core Faculty (Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>Mary Thomas</td>
<td>Core Faculty (Assistant Professor)</td>
<td>50%</td>
</tr>
<tr>
<td>Joel Wainwright</td>
<td>Core Faculty (Assistant Professor)</td>
<td>100%</td>
</tr>
<tr>
<td>John Arnfield</td>
<td>Emeritus Faculty</td>
<td></td>
</tr>
<tr>
<td>Larry Brown</td>
<td>Emeritus Faculty</td>
<td></td>
</tr>
</tbody>
</table>

24
<table>
<thead>
<tr>
<th>Name</th>
<th>Emeritus Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Earl Brown</td>
<td></td>
</tr>
<tr>
<td>Emilio Casetti</td>
<td></td>
</tr>
<tr>
<td>Howard Gauthier</td>
<td></td>
</tr>
<tr>
<td>Henry Hunker</td>
<td></td>
</tr>
<tr>
<td>Duane Marble</td>
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<tr>
<td>Harold Moellering</td>
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<tr>
<td>Joel Morrison</td>
<td></td>
</tr>
<tr>
<td>John Rayner</td>
<td></td>
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</table>
prospective students (and their parents) have indicated strongly that they would prefer to major in atmospheric sciences if they had that option. In particular, our undergraduates tell us that they find it difficult to understand why graduate students may choose either Geography or Atmospheric Sciences given that they do not have the same option. Their feeling is that students with a specialized B.S. in Atmospheric Sciences will be in a much better position to market themselves upon graduation. Our faculty are agreed, and also believe that a stand alone B.S. in Atmospheric Sciences in the Department of Geography is required in order to keep up with our peer institutions as well as fill state, regional and national demand for undergraduate education in the atmospheric sciences.

Geography at Ohio State has an almost ninety year tradition of research and teaching in the atmospheric sciences. Following a 1920 address to the American Meteorological Society, Eugene Van Cleef was invited to establish a climatology program at the Ohio State University in 1921. Van Cleef became a member of the Department of Geography when it was formed and served as a faculty member here until 1973. As a result of this longstanding focus on climatology and physical geography, the department is recognized internationally as top-ranked in atmospheric sciences-based research and teaching. At the undergraduate level the climatology program has evolved into the ACS track, leading to a B.S. in Geography. The Atmospheric Sciences was established as a Graduate Program at Ohio State in 1971, offering both M.S. and Ph.D. degrees. The Atmospheric Sciences Program was co-located with the Department of Geography in 1986.

The topics of study in the atmospheric sciences have expanded considerably since the inauguration of atmospheric sciences in Geography at the Ohio State University. Climatology is now just one important component in a much broader landscape of research and teaching. Current faculty in the Department of Geography offer a wide range of courses, touching on topics such as global warming, climate change, El Niño, hurricanes, floods and other aspects of severe weather.

Our proposed B.S. in Atmospheric Sciences complements the existing B.S. degree in Geography which is undergoing concurrent revisions. It also potentially feeds into our existing M.S. and Ph.D. programs in Geography and in Atmospheric Sciences and it will provide benefits to students in the Department of Geography and the university. The primary reasons for this proposal are that it

1) responds to an existing demand at the undergraduate level for a major in Atmospheric Sciences;
2) fills a need that exists at Ohio State and in the state of Ohio;
3) takes full advantage of the expanded expertise of recent faculty hires; and
4) accurately reflects the broadened nature of the atmospheric sciences. The proposed new major is designed to be consistent with the American
6. Identify any unique characteristics or resources that make it particularly appropriate for Ohio State to offer the proposed major.

The Ohio State University has a number of unique resources that make it the perfect place for a major in Atmospheric Sciences. The Department of Geography has eight full-time tenure track faculty who teach courses in the atmospheric and related sciences. These faculty and their specializations are listed in Appendix A. One of the faculty, Dr. Jeff Rogers, is the State Climatologist for Ohio. The cluster of faculty at Ohio State and the range of their expertise in the atmospheric sciences exceeds those at any other university in Ohio. In addition the department has another cluster of faculty with expertise in Geographic Information Science (GIS) and remote sensing, which are topics central to the analysis and forecasting of atmospheric conditions. The Department of Geography already offers the courses that are required in the proposed major. The department has computer labs for teaching and research in the atmospheric sciences. Derby Hall 1066 serves as the Synoptic Meteorology Laboratory and home to the Meteorology Club. The department maintains a collection of instruments for field research and teaching that offers students “hands-on” experience with data collection and analysis. The department hosts Twister, the Ohio State University Weather Server, which provides real-time meteorological data for educational and informational uses. Twister is highly visible and many official meteorological web sites, including the National Hurricane Center, maintain links to it.

The Meteorology Club supported by the Department of Geography and the Office Student Activities organizes and hosts an Ohio Severe Weather Symposium (OSWS) every April. The OSWS brings in experts from around the U.S. and the state of Ohio to discuss the causes and effects of severe weather. It provides students an excellent opportunity to interact with professionals in the field and to develop their communication and personal skills.

The university has other unique resources that make it particularly appropriate to offer a major in atmospheric sciences. The university is a member of the University Corporation for Atmospheric Research (UCAR), which consists of approximately 60 universities in the U.S. and Canada that offer Ph.D. degrees in the atmospheric and related sciences. The recently completed review of Doctoral Programs at Ohio State rated the program in Atmospheric Sciences as “Strong”. The university is the home of the Byrd Polar Research Center (BPRC), which is a world class facility for research and education in polar meteorology and climate change. The excellent people and extensive facilities at the BPRC provide students with a wide range of opportunities for mentoring and research. The proposed new major also complements the Climate Water Carbon Targeted Investment in Excellence. The Great Lakes Forecasting System (GLFS) was developed as a result of a collaboration between members of the Department of Civil
and Environmental Engineering and Geodetic Sciences and the Atmospheric Sciences Program.

The central location of the university is also a valuable asset for the new major. Students have opportunities for internships at the National Weather Service Forecast Office in Wilmington, at some state agencies, in the private sector with companies like NetJets, and at local media outlets.

7. Cite the benefits for students, the institution, and the region or state.

The purpose of the proposed major is to provide students with the education and experience necessary for them to be successful upon graduation. The specific benefits for the students include

1) an excellent liberal arts education preparing them for career paths in the atmospheric sciences and other fields;
2) a foundation in atmospheric and related sciences necessary for success in a range of career paths;
3) enhanced opportunities for involvement in research, internships and other learning activities; and
4) a major that clearly identifies the nature of their education and interest.

However, by far the biggest benefit for students is that the proposed new major is tailored specifically to fit the needs of students who want to pursue careers in the atmospheric sciences. It is organized to provide the foundation and skills necessary with a clear path to graduation. The major includes sufficient flexibility that the professional undergraduate advisor in Geography can help students choose the courses to satisfy the requirements of the General Education Curriculum (GEC) and their electives to match their specific goals. Students who complete the proposed major will be well positioned to take the next step after they graduate. An additional benefit is that the students’ major will be clearly identified as Atmospheric Sciences, which is something that students and alumni have been requesting for a long time.

The benefits of the proposed major to the Department of Geography are

1) it expands and enhances the existing undergraduate major, which is being modified in a concurrent proposal;
2) it aligns the departmental offerings with the interests of the field and current faculty; and
3) it responds affirmatively to the requests of undergraduates and alumni.

The benefits of the proposed major to the university are
1) it clearly establishes Ohio State as the center for undergraduate education in atmospheric sciences in Ohio;
2) it will help recruit high quality students who would have gone out of state to major in meteorology/atmospheric sciences.; and
3) it complements other university activities such as the Carbon, Water, Climate (CWC) Targeted Investment in Excellence (TIE).

The principle benefit to the university is that the proposed new major will attract some high quality students that would otherwise attend other universities, particularly the regional universities identified above. Prospective students who insist on pursuing a major called Meteorology/Atmospheric Sciences currently do not choose Ohio State, because the university does not offer that major. In addition to adding to the intellectual vitality of the university some of the best students may also choose to continue at Ohio State and do their graduate work in the Atmospheric Sciences Program. The University of Illinois recently recognized the benefits of a similar proposal and approved a new undergraduate major in Atmospheric Sciences. Another benefit for both students and the university is that it would make it easier for students in related disciplines to do double majors.

The principle benefit to the state of Ohio is that the proposed new major would keep more bright and motivated undergraduate students in the state. There is no university in Ohio that currently offers an undergraduate major in meteorology/atmospheric sciences. Thus, any students who insist on a major with that title leave Ohio to go to a university that offers such a major. The proposed new major would also provide a source of potential employees for businesses that require people who can forecast weather or analyze the risk posed by severe and major events. Major insurers like Nationwide Insurance need people who can analyze the potential risk from severe weather and estimate losses after it occurs. Major utilities like American Electric Power need expert forecasters to help predict load demand and to anticipate the need for repair crews when severe weather threatens their service areas. Transportation companies like NetJets employ meteorologists because they require accurate forecasts for route planning, logistical and safety considerations.

8. List similar majors offered in both public and private institutions in Ohio and the U.S. Explain how these majors compare to the one proposed.

No similar majors are offered by any institution within the state of Ohio. Based on information available on the American Meteorological Society’s web site, approximately 29 public and private institutions offer B.S. majors in either Atmospheric Sciences or Meteorology. Penn State and Michigan offer B.S. majors in Meteorology, and Purdue and Illinois offer B.S. majors in Atmospheric Sciences. A list of the universities that offer similar majors is contained in Appendix B. A few of the majors are offered at institutions that only have undergraduate programs. Many of the majors are offered by programs that also offer M.S. and Ph.D. degrees in Meteorology/Atmospheric Sciences. That will be the situation at Ohio State, if the proposed major is approved.
The American Meteorological Society Council adopted a policy statement on the *Bachelor's Degree in Atmospheric Science* on 29 April 2005. The policy statement, which is contained in Appendix G, describes the attributes that should characterize such a degree program. The 29 degree programs listed in Appendix B conform to the policy statement and the attributes listed in it were followed in the design of the proposed major. The proposed major is very similar to a major in Atmospheric Sciences recently approved at the University of Illinois. The primary differences between the proposed major and the similar majors at other institutions are found in the electives available to students. No institution attempts to cover all of the specializations in the atmospheric sciences. Institutions tend to cluster faculty in a few specializations that represent their areas of emphasis. The electives in the proposed major reflect the expertise and areas of emphasis of the faculty at Ohio State.

9. **Cite the enrollment patterns of similar majors in Ohio or in the United States.**

Periodic surveys conducted by the American Meteorological Society and the University Corporation for Atmospheric Research reveal that approximately 1000 undergraduates in the U.S. are pursuing a B.S. in Meteorology/Atmospheric Sciences at any given time. This number has remained relatively steady over the past 10-15 years. The specific enrollment data cited in this proposal were gathered from the American Meteorological Society’s web site and from requests to specific well-regarded programs in the Big Ten and the U.S. The available data are contained in Appendix B.

As can be seen in Appendix B, the enrollments range from 20-30 students in the smaller programs to approximately 300 students at Penn State and the University of Oklahoma. Typical programs have roughly 50-150 undergraduates in their majors. The programs with the fewest number of majors tend to be at private institutions or in programs that only offer B.S. degrees. The programs with the larger number of major tend to be at public institutions and offer M.S. and Ph.D. degrees as well as a B.S.

10. **Describe career opportunities and/or opportunities for graduate or professional study available to persons who complete the major.**

Undergraduates who complete the proposed major will have the foundation to apply successfully to highly regarded graduate programs in meteorology/atmospheric sciences. The requirements of the proposed major exceed the entrance requirements of those graduate programs. Students who indicate an interest in graduate study will be advised to maximize their opportunities through involvement in internships and summer programs, and will be strongly encouraged to participate in research projects.

The proposed major contains the courses necessary for undergraduates who are interested in a career as a weather forecaster. Students who complete the major will fulfill all of the Federal Civil Service Requirements for Meteorologist Positions (GS 1340). This will qualify the students for meteorology positions in the National Weather Service,
the Federal Aviation Administration or any other Federal agency. Students in ROTC will be qualified for meteorology positions in their respective branch of the Armed Services. Students will also be qualified for weather forecasting positions in the private sector, since most private companies base their expectations on the Federal GS 1340 requirements. Students who indicate interest in careers in weather forecasting will be strongly advised to participate in internships at the National Weather Service Forecast Office in Wilmington or at private companies in order to acquire additional practical experience. Students currently prepare a daily local forecast that appears on the front page of The Ohio State University Weather Server – Twister. The nature of the rotating shifts worked by forecasters in both the public and private sector and the need to forecast the weather 24 hours a day, seven days a week ensures a constant turnover and job opportunities. Organizations like the American Meteorological Society and the National Weather Association regularly post new announcements of openings for weather forecasters on their web sites.

Undergraduates who are interested in a career as an on-air meteorologist will receive an excellent background in the fundamentals of meteorology and in the techniques used to analyze and display meteorological information. Students who indicate an interest in becoming an on-air meteorologist will be advised to take Communications and other courses to supplement their meteorological training. They will also be strongly encouraged to participate in internships with local media in order to get valuable practical experience and make necessary professional contacts. Persons entering the field of on-air meteorology generally begin in smaller markets at modest salaries. Individuals with talent, skill and motivation can quickly progress to larger markets with much higher salaries.

The proposed major contains sufficient flexibility for undergraduates who are interested in careers in environmental monitoring, consulting, applications development or some aspect of the atmospheric sciences besides weather forecasting and on-air meteorology.

The American Meteorological Society, the University Corporation for Atmospheric Research and other organizations periodically conduct surveys of starting salaries for atmospheric scientist. Estimated starting salaries based on a compilation of those data for three career paths are presented in Table 1.

<table>
<thead>
<tr>
<th>Degree</th>
<th>B.S.</th>
<th>M.S.</th>
<th>Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private Sector</td>
<td>$18,000.- $30,000.</td>
<td>$30,000.- $40,000.</td>
<td>$40,000.- $60,000.</td>
</tr>
<tr>
<td>Government</td>
<td>$28,000.- $34,500.</td>
<td>$42,000. - $54,000.</td>
<td>$70,000. -</td>
</tr>
<tr>
<td>Academic</td>
<td></td>
<td></td>
<td>$45,000. - $80,000.</td>
</tr>
</tbody>
</table>
11. Describe any licensure or certification for which this major will prepare students.

The American Meteorological Society (AMS) has programs that certify the credentials of meteorologists/atmospheric scientists in two career paths. The Certified Broadcast Meteorologist Program awards the AMS Seal of Approval to those individuals who fulfill the requirements of that program. Completion of the proposed major will fulfill one of the requirements for the Seal of Approval. The AMS Certified Consulting Meteorologist Program is available for meteorologists who work as consultants in the private sector. Completion of the proposed major will fulfill one of the requirements for that certification and will prepare students for the written and oral exams they will have to pass to become certified.

III. GOALS/OBJECTIVES/EVALUATION

12. Provide a learning outcomes assessment plan for the major program.

A. State the general and specific educational goals and objective for the major.

The goal of the proposed major is to provide students with a foundation in basic atmospheric and related sciences, mathematics and statistics, while providing sufficient flexibility and breadth so students can pursue a number of different career paths. It is designed to allow students to acquire an appropriate combination of fundamental knowledge, core competencies and skills for their chosen goals. The courses required for the major are chosen to provide students opportunities to develop critical thinking and communication skills including problem solving, reasoning, analytical and other relevant professional skills.

Students who want to major in atmospheric sciences typically have the following goals:

1) to pursue graduate education in the atmospheric sciences and become research scientists;
2) to become weather forecasters in either the public or private sector;
3) to become on-air meteorologists; or
4) to acquire a more broadly based liberal arts education focused on their interest in the atmospheric sciences.

This proposed major is designed to provide the rigor and foundation for students who want to do research and to provide the flexibility, knowledge and skills for those students who want pursue other opportunities.

The general educational goals of the proposed major are:

1) to provide students with a core foundation of knowledge in the atmospheric and related sciences;
2) to prepare students for graduate study in atmospheric science or a closely related field through advanced education with a focus on critical thinking and problem solving; and
3) to prepare students for a successful career through advanced education and training in the relevant professional skills.

The specific educational goals for the proposed major are:

1) to provide students with the theoretical basis for fundamental atmospheric processes and systems;
2) to develop students' ability to solve problems faced by atmospheric scientists;
3) to introduce students to computational and other forms of technology used in the atmospheric sciences.

B. Indicate the methods that will be used to assess whether the educational goals and objectives are being met.

The Department of Geography currently has an assessment plan that includes a suite of outcome monitoring methods that allows us to gauge whether or not it is meeting pedagogical goals and to make necessary corrections. The plan is reviewed annually by the College of Social and Behavioral Sciences, and it is managed by the department's professional undergraduate advisor. The plan consists of two indirect assessment methods and one direct method. The assessment methods include:

1) embedded questions in the exams given in one regularly offered and popular upper division undergraduate course;
2) informal focus groups with students in the major (e.g. In the 2007-2008 academic year there were four focus groups representing each of the specializations within the major); and
3) an exit survey of graduating seniors, which includes questions about the major regarding their overall educational experience, classroom experience, research and internship participation, and placement in jobs and in graduate schools.

The Department of Geography is conducting a concurrent revision to its undergraduate major and is developing an improved assessment strategy. The department is in the process of refining the methods it uses for assessment. The intention is to take the information gained during the assessment process to date and to improve the preparation of students for graduate studies and the job market. In addition the department is gaining experience with the methods of assessment and an ongoing evaluation of those methods will lead to better assessment of the major.

Because the proposed major will be within the Department of Geography it will be able to take advantage of the experience the department has with assessment. The initial
assessment plan consists of similar elements to those already used by Geography. They include:

1) the use of existing questions in Atmospheric Sciences 638;
2) informal focus groups with undergraduate majors and members of the Meteorology Club; and
3) exit interviews with graduating seniors.

Atmospheric Sciences 638 (Dynamic Meteorology II) is a course that many students will take as one of the last courses required for their major. Most students will have already taken courses dealing with synoptic meteorology and boundary layer processes. Some of the topics covered in Atmospheric Sciences 638 include the derivations of the theoretical bases for many important concepts in synoptic meteorology. There are also discussions of the assumptions made during the derivations and the limitations imposed by those assumptions on the applications of the resulting concepts. In addition some of the material covered in Atmospheric Sciences 638 links the processes in the boundary layer to the processes operating in the rest of the large scale atmosphere. Thus, some of the questions on examinations in Atmospheric Sciences 638 provide an opportunity to assess students’ acquisition of a core foundation of knowledge in the atmospheric sciences. The performance of the students on specific questions will be reviewed by faculty who teach courses in the proposed major and curriculum changes will be discussed and implemented as necessary. Those faculty already meet both formally and informally to discuss curriculum issues.

Focus groups will be conducted without faculty present in order to encourage students to feel free to be open with their opinions. Students’ opinions on individual courses required for the proposed major and on the structure and requirements of the major will be solicited. The results of the focus groups will be conveyed to the faculty and changes to the major will be considered as appropriate.

Exit interviews will include questions about the future plans of graduating seniors. In addition to providing additional opinions on the structured and requirements of the proposed major, the exit interviews will provide data in the ability of graduating seniors to get into graduate programs and to find employment. This information will enable the department to assess if the proposed major is meeting its goal of preparing students for those options. The information gathered during the exit interviews will be reviewed and discussed by the faculty and changes to the major will be considered as appropriate.

C. Provide the time over which the assessment plan will be implemented.

Because this will be a new major, the implementation of the assessment methods will be introduced gradually.
Year 1 – Focus groups

Year 2 – Focus groups, assess questions in Atmospheric Sciences 638

Year 3 – Focus groups, assess questions in Atmospheric Sciences 638, exit interviews,

Year 4 – Focus groups, assess questions in Atmospheric Sciences 638, exit interviews,
review assessment plan.

IV. RELATIONSHIP TO OTHER PROGRAMS

13. Describe current major and minor programs in the department(s) and how they relate to the proposed major.

The current major in Geography contains an Atmospheric and Climatic Studies (ACS) track. The details of the current major are contained in Appendix C. The current structure of the ACS track contains two paths in Atmospheric Sciences and in Climatic Studies. The Climatic Studies path represents an evolution of the Geography's original specialization in climatology and it is a path typically found in many Geography departments around the U.S. Students in the Climatic Studies path are provided with the foundation necessary to analyze climate and climate change and are exposed to a broader geographical education. The Atmospheric Sciences path was developed in attempt to address the needs and requests of students who wanted to pursue graduate education or other career opportunities in the atmospheric sciences. The Atmospheric Sciences path requires students to complete three additional Mathematics courses (i.e. through differential equations), and requires students to complete courses providing a thorough theoretical foundation in atmospheric sciences. The Atmospheric Sciences path was designed using all of the relevant courses offered by the Department of Geography at the time it was created.

The Department of Geography has subsequently hired additional faculty in the atmospheric sciences and has expanded both the range and level of the courses it offers in that area. The department is undertaking a thorough re-examination and modification of all of the undergraduate tracks in a separate proposal being developed concurrently with this proposal. The existing Atmospheric and Climatic Studies (ACS) track in Geography is being completely revamped and will become the Climatology and Physical Geography (CPG) track. The details of proposed CPG track are contained in a separate proposal and are listed in Appendix D. The Atmospheric Sciences path is being eliminated in the proposed revisions to the Geography major, contingent upon approval of this proposal.

The requirements of the proposed new major in Atmospheric Sciences are more rigorous than those for the current Atmospheric Sciences path. Students will be
required to take an additional physics course (Physics 133), a Chemistry course (Chemistry 121), and two additional courses in their major (chosen from a list of electives in the major). These additional requirements will make the proposed major consistent with the attributes listed in the American Meteorological Society’s Policy Statement on Bachelor’s Degree in Atmospheric Science and will make students who complete the major competitive with graduates of other universities around the U.S.

The proposed major differs from the existing M.S. in Atmospheric Sciences in both the required level knowledge and skills. Students pursuing a M.S. degree must take graduate-only seminars in addition to their other coursework. Students who successfully complete a M.S. degree must demonstrate a higher level of knowledge in specific areas in comprehensive written and oral examinations and demonstrate research competency by writing a Thesis.

14. Identify any overlaps with other programs or departments within the University. Append letters of concurrence or objection form related units.

There is no overlap with other majors or programs within the university.

15. Indicate any cooperative arrangement with other institutions and organizations that will be used to offer this major.

None.

16. Specify any articulations arrangements (direct transfer opportunities) with other universities that will be in effect for the major.

None.

17. Provide information on the use of consultants or advisory committees in the development of the major. Describe any continuing consultation.

Initial consultations were held with all members of the Department of Geography who teach courses in the current Atmospheric and Climatic Studies (ACS) track. Ideas about the content and structure of the proposed major were discussed. The opinions of some alumni were solicited. Consultations continued with the faculty and a consensus was achieved about the content and structure of the major. A focus group of undergraduates in the current ACS track or in the Meteorology Club was convened in Spring Quarter of 2007. The focus group strongly favored the proposed major and responded positively to its content and structure. The proposed major was discussed by the Undergraduate Curriculum Committee in Geography and at a subsequent departmental faculty meeting. Minor modifications to the proposal were made and unanimously endorsed by the faculty in the ACS track. If substantial modifications to
the structure and content of the proposed major are required, the faculty will be consulted and their endorsement will be sought.

18. Indicate whether this major or a similar major was submitted for approval previously. Explain at what stage and why that proposal was not approved or was withdrawn.

This proposed major has never been submitted previously for approval.

19. Indicate where students will be drawn from, e.g. existing academic programs, outside the university, etc. Estimate the mix of students entering the major internally and externally.

The projections in this section are based on discussions with current undergraduate students in the Atmospheric and Climatic Studies (ACS) track and the professional undergraduate adviser in the Department of Geography. It is projected that a large percentage of undergraduates currently in the ACS track will switch to the proposed major. The projection is that 51 students will switch from the ACS track to the proposed major. In addition we project 5 new students will choose the proposed major. As the proposed major becomes more widely known, it is anticipated that the number of new students choosing the major will increase, as indicated by the projections in the answer to Question 20. Most of the increase in entering students who choose the proposed major will be comprised of students who will not attend Ohio State, if the proposed major is not available. There will likely be 1-3 students each year who change majors and choose the proposed major, but most of the new majors will arrive from outside Ohio State. Many students who choose to major in the meteorology/atmospheric sciences at other universities declare that major as incoming freshman. It is anticipated that a similar pattern will occur at Ohio State. It is anticipated that the number of undergraduates in the proposed major will level off at between 90-120 students. This projection is consistent with the enrollment in similar majors at other universities and would be an appropriate size for the proposed major.

V. STUDENT ENROLLMENT

20. Indicate the number of students you anticipate will be admitted to the major each year.

<table>
<thead>
<tr>
<th>Student type</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full time (new entering)</td>
<td>56</td>
<td>9</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Full time (cumulative)</td>
<td>56</td>
<td>65</td>
<td>76</td>
<td>91</td>
</tr>
<tr>
<td>Summer enrollment</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
VI. REQUIREMENTS

21. List the courses (department, title, credit hours, description) which constitute the requirements and other components of the major. Indicate which courses are currently offered and which will be new. Append a quarter-by-quarter sample program and all New Course, Course Change, and Course Withdrawal forms necessitated by the implementation of the proposed major.

The requirements for the major are contained in Appendix E. A quarter-by-quarter sample program is contained in Appendix F. The curriculum consists of 181 credit hours including the required one credit hour university survey course. The Required Prerequisites and Supplements to the major consist of 50 credit hours, but 35 of those hours may also be applied to the General Education Curriculum (GEC) requirements for B.S. degrees in the Colleges of the Arts and Sciences. The Core Courses in the major consist of 43 credit hours. The Major Electives consist of 8-10 credit hours depending on which courses students choose. Thus, there are 51-53 total credit hours required in the proposed major. The GEC for B.S. students consists of 100 credit hours, but 35 of those credit hours overlap with the Required Prerequisites and Supplements to the major. Therefore, a student will have 12-14 credit hours of Free Electives unencumbered by the other requirements for graduation. Students will be advised about which GEC courses and Free Electives are most appropriate for their interests and career aspirations.

Three new courses are being proposed as part of the new major. Atmospheric Sciences 689 (Student Internship in Atmospheric Sciences), Atmospheric Sciences 699 (Undergraduate Research in Atmospheric Sciences) and Atmospheric Sciences H783 (Honors Research) are being proposed as a result of input from students and alumni that indicated they wanted something on their transcripts that clearly indicated their internships or research were in atmospheric sciences. Copies of the proposals for these new courses are attached to this proposal. The major also includes a new course, Geography 684 (Geographic Applications of Remote Sensing), that is being proposed by the Department of Geography as a part of the revision to the B.S. major in Geography.

22. State the minimum number of credit required for completion of the major.

The minimum number of credit hours required for the major is 51.

23. State the average number of credits expected for a student at completion of their major.

We expect most students to have 53 major credit hours when they graduate, based on the average number of credits in the elective courses.
24. Give the average number of credits taken per quarter by a typical student. 
   Estimate the average for each year.

   A typical student takes an average of 15 credit hours per quarter. A typical student 
   takes an average of 45 credit hours per year.

25. Given the number of credits a student is required to take in other departments.

   Students are not required to take any credit hours in their major in other departments. 
   Students may choose to take 5 credit hours in Geological Sciences or 4-8 hours in Civil 
   Engineering if they choose those courses for their Major Electives. Students are 
   required to take 25 credit hours in Mathematics, 15 credit hours in Physics, 5 credit 
   hours in Chemistry and 5 credit hours in Statistics as part of their Required Prerequisites 
   and Supplements to the Major.

26. Give the number of credits a typical student might take as electives in other 
    departments.

   The typical student might take 12-30 credit hours as electives in other departments. 
   The number of credit hours and specific courses taken by an individual student will 
   depend the student’s career goals and area of interest within the atmospheric sciences.

27. Describe other major requirements in addition to course requirements, e.g., 
    examinations, internships, final projects.

   None.

28. Identify from which specialized professional association(s) accreditations will be 
    sought. List additional resources that will be necessary to gain such accreditation.

   No accreditation will be sought from professional associations. Although the American 
   Meteorological Society has discussed the possibility of developing an accreditation 
   program from time to time, it has always decided against doing so.

29. Describe the number and qualifications of full-time or part-time faculty. List 
    current faculty and areas of expertise. Describe the number and type of additional 
    faculty needed.

   There are eight full time tenure track faculty who will teach courses in the proposed 
   major. The list of the faculty and their areas of expertise are listed in Appendix A. In 
   addition to the specializations listed in Appendix A Dr. Rogers is the State Climatologist 
   for Ohio. Dr. Mosley-Thompson has received numerous awards for her distinguished 
   work in paleoclimatology and climate change and Dr. Hobgood received an Alumni 
   Distinguished Teaching Award in 1996. So, the faculty who will be teaching courses and
mentoring students in the proposed major are extremely well-qualified to do so. No new faculty are required for the establishment of this major. If opportunities arise to hire additional faculty who can contribute to this proposed major, the major will be revised appropriately.

30. Describe existing facilities, equipment, and off-campus field experiences to be used. Indicate how the use of these facilities, equipment, etc. will impact other existing programs.

The Department of Geography has computer labs for teaching and research in the atmospheric sciences. There are sufficient resources in the labs to handle any additional students in courses taught in those labs generated by the proposed new major. Derby Hall 1066 already serves as the Synoptic Meteorology Laboratory and home to the Meteorology Club. There is sufficient space in that room to accommodate the increased number of students projected for the new major. The Department of Geography maintains a collection of instruments for field research and teaching that offers students "hands-on" experience with data collection and analysis. The department has sufficient resources to acquire additional instruments if the number of students in the new major exceeds expectations. Thus, the additional students generated by the proposed major should not have a major impact on existing facilities and equipment.

Specifically, the Department of Geography uses Derby 0140 as its primary instructional computer laboratory. Several of the courses required in the proposed major are already being taught in that lab. There are open seats available when those courses are taught. Derby 0140 contains 50 state-of-the-art workstations and each is equipped with a full complement of relevant software. The lab is managed by two full-time technical staff and a graduate student. The department is confident that its existing staff will be able to manage the increased usage of the lab. There is sufficient space in the lab to expand the number of workstations by 30%, if the number of majors increases beyond the projections. Undergraduates are free to use the workstations in Derby 0140 for class assignments and research projects when no classes are being taught in the lab. This generally means that students have access to those machines at most times between 5:00 p.m. and 9:00 a.m.

The Department is preparing a spacious new undergraduate student resource center. The designation of this space specifically for undergraduates will give students in the proposed major a dedicated space, when they need to work in Derby. Computers will be installed in the center, which will further increase the number of machines available to undergraduates working on class assignments or research projects. The resource center will supplement the space in the Synoptic Meteorology Laboratory in Derby 1066 for the Meteorology Club. Undergraduates in the proposed major will have multiple places in Derby Hall where they can work.
31. Describe additional University resources, including libraries that will be required for the new major.

None.

32. Describe the major as it would appear in the appropriate college bulletin.

The undergraduate Atmospheric Sciences major examines atmospheric processes and systems that occur at many spatial and temporal scales. A fundamental understanding of the theoretical basis of atmospheric transfers of matter and energy provides the foundation necessary to analyze systems of varying sizes and intensities. These theories provide the framework used to analyze current patterns of weather and climate and to predict future changes of weather and climate. Numerical models of the atmosphere solve equations based on these theories and are used to provide forecasts at many scales.

The major is designed to prepare students for a variety of career paths. The major emphasizes a strong fundamental background to prepare students for a lifetime of learning as knowledge about weather and climate advances. The strong background will serve students who desire a career in research and those who are more interested in operational meteorology well. Applications of computers and other technology in the atmospheric sciences continue to expand. Students are introduced to technology used by atmospheric scientists and are encouraged to develop their computational skills. The requirements for the major and the available electives provide sufficient flexibility for students to be able to tailor a program of study for their particular interests.

Students graduating with a major in Atmospheric Sciences will be well prepared to compete for admission to graduate programs in meteorology or atmospheric sciences and to find gainful employment in the public and private sector. Students who desire advanced training at the graduate level will have the foundation necessary to contribute to research projects and be successful. Students who are interested in jobs in operational or broadcast meteorology will have the knowledge and training to be able to negotiate successfully the challenges of those professions. Graduates will have the background to enable them to add value and make positive contributions to their chosen endeavors.
Appendix A
Faculty

Box, Jason (Assistant Professor), Global Energy and Mass Balances, Climate Change.

Bromwich, David (Professor), Polar Meteorology and Climatology, Climate Theory: Modeling and Diagnostics, Cryosphere, Mesoscale Meteorology and Modeling, Precipitation, Operational Weather Prediction.

Hobgood, Jay (Associate Professor), Hurricanes, Tropical Cyclones, Atmospheric Thermodynamics, Dynamic Meteorology.

Lin, Jialin (Assistant Professor), Global Climate Modeling, Tropical Dynamics, Tropical Convection and Clouds.

Mark, Bryan (Assistant Professor), Climatology, Paleoclimatology, Mountain Climate, Tropical Glaciers, Glacier-Climate Dynamics, Climate-Change Impacts.

Mosley-Thompson, Ellen (Professor), Paleoclimatology, Ice Cores, Climate variability and Change, Abrupt Climate Change, Volcanic Aerosols, Polar Climatology.

Porinchu, David (Assistant Professor), Global Change, Paleoclimatology, Paleoeology, Biogeography, Climate Change.

Rogers, Jeffery (Professor), Climatology, Climatic Change, Synoptic Meteorology.
## Appendix B

### Similar Majors at Other Universities in the U.S.

<table>
<thead>
<tr>
<th>University</th>
<th>Degree Offered</th>
<th>Estimated Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Univ. of California at Davis</td>
<td>B.S. Atm. Sc.</td>
<td>25</td>
</tr>
<tr>
<td>UCLA</td>
<td>B.S. Atm. Sc.</td>
<td>35</td>
</tr>
<tr>
<td>Creighton Univ.</td>
<td>B.S. Atm. Sc.</td>
<td>20</td>
</tr>
<tr>
<td>Florida St. Univ.</td>
<td>B.S. Meteor.</td>
<td>160</td>
</tr>
<tr>
<td>Georgia Tech.</td>
<td>B.S. Earth and Atm. Sc.</td>
<td>60</td>
</tr>
<tr>
<td>Univ. of Hawaii at Manoa</td>
<td>B.S. Meteor.</td>
<td>20</td>
</tr>
<tr>
<td>Univ. of Illinois</td>
<td>B.S. Atm. Sc.</td>
<td>New major</td>
</tr>
<tr>
<td>Iowa State Univ.</td>
<td>B.S. Meteor.</td>
<td>NA</td>
</tr>
<tr>
<td>Lyndon St. Col.</td>
<td>B.S. Meteor.</td>
<td>55</td>
</tr>
<tr>
<td>Univ. of Missouri-Columbia</td>
<td>B.S. Atm. Sc.</td>
<td>70</td>
</tr>
<tr>
<td>Univ. of Michigan</td>
<td>B.S. Meteor.</td>
<td>NA</td>
</tr>
<tr>
<td>Univ. of Nebraska-Lincoln</td>
<td>B.S. Meteor.</td>
<td>65</td>
</tr>
<tr>
<td>North Carolina St. Univ.</td>
<td>B.S. Meteor.</td>
<td>125</td>
</tr>
<tr>
<td>University of Nevada-Reno</td>
<td>B.S. Atm. Sc.</td>
<td>NA</td>
</tr>
<tr>
<td>Univ. of North Carolina-Asheville</td>
<td>B.S. Atm. Sc.</td>
<td>100</td>
</tr>
<tr>
<td>Northern Illinois Univ.</td>
<td>B.S. Meteor.</td>
<td>NA</td>
</tr>
<tr>
<td>SUNY at Albany</td>
<td>B.S. Atm. Sc.</td>
<td>NA</td>
</tr>
<tr>
<td>Oklahoma Univ.</td>
<td>B.S. Meteor.</td>
<td>310</td>
</tr>
<tr>
<td>Penn. St. Univ.</td>
<td>B.S. Meteor.</td>
<td>300</td>
</tr>
<tr>
<td>Purdue Univ.</td>
<td>B.S. Atm. Sc.</td>
<td>60</td>
</tr>
<tr>
<td>San Jose St. Univ.</td>
<td>B.S. Meteor.</td>
<td>NA</td>
</tr>
<tr>
<td>S. Dakota School of Mines and Tech.</td>
<td>B.S. Atm. Sc.</td>
<td>NA</td>
</tr>
<tr>
<td>Texas A&amp;M Univ.</td>
<td>B.S. Atm. Sc.</td>
<td>150</td>
</tr>
<tr>
<td>Texas Tech. Univ.</td>
<td>B.S. Atm. Sc.</td>
<td>NA</td>
</tr>
<tr>
<td>Univ. of Utah</td>
<td>B.S. Meteor.</td>
<td>90</td>
</tr>
<tr>
<td>Univ. of Wisconsin-Madison</td>
<td>B.S. Atm. Sc.</td>
<td>120</td>
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<tr>
<td>Univ. of Washington</td>
<td>B.S. Atm. Sc.</td>
<td>NA</td>
</tr>
<tr>
<td>Univ. of North Dakota</td>
<td>B.S. Atm. Sc.</td>
<td>75</td>
</tr>
<tr>
<td>Rutgers</td>
<td>B.S. Atm. Sc.</td>
<td>50</td>
</tr>
</tbody>
</table>

NA – The estimated enrollment was Not Available.
Appendix C. Current Atmospheric and Climatic Studies Curriculum

Part A. Required Prerequisites or Supplements to the Major

1. Atmospheric Sciences path
   - Math 151, 152, 153, 254, 415
   - Physics 131, 132
   - Statistics 245

2. Climatic Studies path
   - Math 151, 152
   - Physics 131, 132
   - Statistics 245

Part B. Core Requirements

1. For both Atmospheric Science and Climatic Studies paths
   - Basic Meteorology AS 230 OR Climatology Geog 520
   - Synoptic Meteorology Laboratory AS/Geog 620
   - Boundary Layer Climatology Geog 622.01
   - Microclimatological Measurements Geog 622.02
   - Synoptic Analysis and Forecasting Geog 623.01
   - Severe Storm Forecasting 623.02

2. Additional for the Atmospheric Science path
   - Atmospheric Thermodynamics AS 631
   - Dynamic Meteorology I AS 637
   - Dynamic Meteorology II AS 638

3. Additional for the Climatic Studies path
   - Introduction to Cartography Geog 580
   - Undergraduate Seminar in Applied Geography Geog 695 OR Seminar in Geography Geog 795
   - Any Human Geography course 600-level or higher

Part C. Electives within the Major

- NA
Appendix D. Proposed Climatology and Physical Geography Curriculum

Part A. Required Prerequisites or Supplements to the Major
1. For Climatic Studies path
   - Math 151, 152, 153
   - Physics 131, 132
   - Statistics 245
2. For the Physical Geography path
   - Math 151, 152
   - Physics 131
   - Statistics 245

Part B. Core Requirements
1. For Climatic Studies path
   - Basic Meteorology AS 230 OR Climatology Geog 520
   - Synoptic Meteorology Laboratory AS/Geog 620
   - Boundary Layer Climatology Geog 622.01
   - Microclimatological Measurements Geog 622.02
   - Synoptic Analysis and Forecasting Geog 623.01
   - Severe Storm Forecasting 623.02
2. For Physical Geography path
   - Introduction to Physical Geography Geog 220
   - Global Climate Change: Causes and Consequences Geog 420
   - Biogeography: An Introduction to Life on Earth Geog 490
   - Basic Meteorology AS 230 OR Climatology Geog 520
   - Integrated Earth Systems: Confronting Global Change Geog 597.02
   - Geomorphology Earth Sci 550

Part C. Electives within the Major
1. For Climatic Studies path. Choose five of the following courses:
   - Climate System Modeling: Basics and Applications AS 629
   - Atmospheric Thermodynamics AS 631
   - Dynamic Meteorology I AS 637
   - Dynamic Meteorology II AS 638
   - Physical Geography and Environmental Issues Geog 210
   - Global Climate Change: Causes and Consequences Geog 420
   - Biogeography: An Introduction to Life on Earth Geog 490
   - Introduction to Cartography Geog 580
   - Integrated Earth Systems: Confronting Global Change Geog 597.02
   - Fundamentals of Geographic Information Systems Geog 607
   - Undergraduate Research and Professionalization Seminar Geog 695 OR Seminar in Geography Geog 795
2. For Physical Geography path. Choose five of the following courses (at most one may be from Earth Sciences):
   - Physical Geography and Environmental Issues  Geog 210
   - Introduction to Cartography  Geog 580
   - Computer Cartography and Geographic Visualization 680
   - Fundamentals of Geographic Information Systems  Geog 607
   - Intermediate Geographic Information Systems  Geog 685
   - Undergraduate Research and Professionalization Seminar Geog 695 OR Seminar in Geography  Geog 795
   - One Human Geography course 600-level or higher
   - Synoptic Meteorology Laboratory  AS/Geog 620
   - Boundary Layer Climatology  Geog 622.01 (note: has prerequisite of Physics 132, which has a prerequisite of Math 153)
   - Microclimatological Measurements Geog 622.02 (note: has prerequisite of Physics 132, which has a prerequisite of Math 153)
   - Synoptic Analysis and Forecasting  Geog 623.01 (note: has prerequisite of Physics 132, which has a prerequisite of Math 153)
   - Severe Storm Forecasting  623.02 (note: has prerequisite of Physics 132, which has a prerequisite of Math 153)
   - Climate System Modeling: Basics and Applications  AS 629
   - Atmospheric Thermodynamics  AS 631 (note: has a prerequisite of Math 153)
   - Dynamic Meteorology I  AS 637 (note: has prerequisite of Math 255)
   - Dynamic Meteorology II  AS 638
   - Principles of Oceanography  Earth Sci 206
   - Water in the Basin Hydrologic Cycle  Earth Sci 410
   - Glaciers and Landscapes  Earth Sci 650

Part D. Internship
1. After students have completed 20 hours of coursework in Geography, they are eligible for an internship and receive credit for it through the department.
Appendix E. Proposed Atmospheric Sciences Major

Atmospheric Sciences Major

The Atmospheric Sciences major provides core foundation of knowledge in the atmospheric sciences with emphases on theoretical concepts and techniques of analysis and problem solving.

Part A. Required Prerequisites or Supplements to the Major. (Do not count toward the credit hours required in the major)

<table>
<thead>
<tr>
<th>Courses</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 151 – Calculus and Analytic Geometry I</td>
<td>5</td>
</tr>
<tr>
<td>Math 152 – Calculus and Analytic Geometry II</td>
<td>5</td>
</tr>
<tr>
<td>Math 153 – Calculus and Analytic Geometry III</td>
<td>5</td>
</tr>
<tr>
<td>Math 254 – Calculus and Analytic Geometry IV</td>
<td>5</td>
</tr>
<tr>
<td>Math 255 – Differential Equations and Their Applications</td>
<td>5</td>
</tr>
<tr>
<td>Physics 131 – Introductory Physics: Particles and Motion</td>
<td>5</td>
</tr>
<tr>
<td>Physics 132 – Introductory Physics: Electricity and Magnetism</td>
<td>5</td>
</tr>
<tr>
<td>Physics 133 – Introductory Physics: Thermal Physics, Waves and Quantum Physics</td>
<td>5</td>
</tr>
<tr>
<td>Chemistry 121 – General Chemistry</td>
<td>5</td>
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<tr>
<td>Statistics 245 – Introduction to Statistical Analysis</td>
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Part B. Core Requirements. (43 hours)

<table>
<thead>
<tr>
<th>Courses</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Atmospheric Sciences 230 – Basic Meteorology</td>
<td>5</td>
</tr>
<tr>
<td>Or</td>
<td></td>
</tr>
<tr>
<td>Geography 520 – Climatology</td>
<td>5</td>
</tr>
<tr>
<td>Atmospheric Sciences/Geography 620 – Synoptic Meteorology Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>Geography 622.01 – Boundary Layer Climatology</td>
<td>5</td>
</tr>
<tr>
<td>Geography 622.02 – Microclimatological Measurements</td>
<td>5</td>
</tr>
<tr>
<td>Geography 623.01 – Synoptic Analysis and Forecasting</td>
<td>5</td>
</tr>
<tr>
<td>Geography 623.02 – Severe Storm Forecasting</td>
<td>5</td>
</tr>
<tr>
<td>Atmospheric Sciences 631 – Atmospheric Thermodynamics</td>
<td>5</td>
</tr>
<tr>
<td>Atmospheric Sciences 637 – Dynamic Meteorology I</td>
<td>5</td>
</tr>
<tr>
<td>Atmospheric Sciences 638 – Dynamic Meteorology II</td>
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**Part C. Major Electives** (Choose two courses from the list below)

<table>
<thead>
<tr>
<th>Courses</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>Atmospheric Sciences 629 – Climate System Modeling: Basics and Applications</td>
<td>5</td>
</tr>
<tr>
<td>Geography H410 – Global Climate and Environmental Change</td>
<td>5</td>
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<td><strong>Or</strong></td>
<td></td>
</tr>
<tr>
<td>Geography 420 Global Climate Change: Causes and Consequences</td>
<td>5</td>
</tr>
<tr>
<td>Geography 597.02 – Integrated earth Systems: Confronting Global Change</td>
<td>5</td>
</tr>
<tr>
<td>Geography 607 – Fundamentals of Geographic Information Systems</td>
<td>5</td>
</tr>
<tr>
<td>Geography 684 – Geographic Applications of Remote Sensing</td>
<td>5</td>
</tr>
<tr>
<td>Geological Sciences 206 – Principles of Oceanography</td>
<td>5</td>
</tr>
<tr>
<td>Civil Engineering 603 – Remote Sensing</td>
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</tr>
<tr>
<td>Civil Engineering 613 – Principles of Applied Hydrology</td>
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## Appendix F. Sample Four Year Plan

### Sample four year plan B.S. Atmospheric Sciences

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Autumn</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
<td></td>
<td>English 110</td>
<td>Math 151 (Pre-major and GEC)</td>
<td>Math 152 (Pre-major and GEC)</td>
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<tr>
<td></td>
<td>Math 150</td>
<td>First Foreign Language course</td>
<td>Physics 131 (Pre-major and GEC)</td>
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<td></td>
<td>First GEC Social Science course</td>
<td>Visual/Performing Arts</td>
<td>Second Foreign Language course</td>
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<td>University Survey course (1 hour)</td>
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<tr>
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<td>Math 153</td>
<td>Math 254</td>
<td>Math 255</td>
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</tr>
<tr>
<td></td>
<td>Physics 132 (Pre-major and GEC)</td>
<td>Physics 133 (Pre-major)</td>
<td>Atmospheric Sciences 230 (or)</td>
<td></td>
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<tr>
<td></td>
<td>Third Foreign Language course</td>
<td>Fourth Foreign Language course</td>
<td>Geography 520</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GEC Second Writing course</td>
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<table>
<thead>
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<th>Year 3</th>
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<th>Summer</th>
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<tbody>
<tr>
<td></td>
<td>Atmospheric Sciences 631</td>
<td>Geography 622.01</td>
<td>Geography 623.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geography 620</td>
<td>Geography 623.01</td>
<td>Chemistry 121 (Pre-major and GEC)</td>
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</tr>
<tr>
<td></td>
<td>Statistics 245</td>
<td>Second GEC Social Science course</td>
<td>Literature</td>
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<table>
<thead>
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<th>Spring</th>
<th>Summer</th>
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<tbody>
<tr>
<td></td>
<td>Geography 622.02</td>
<td>Atmospheric Sciences 637</td>
<td>Atmospheric Sciences 638</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Civil Engineering 206 (M.Elective)</td>
<td>Earth Sciences 206 (M.Elective)</td>
<td>Fourth GEC Science course (must)</td>
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</tr>
<tr>
<td></td>
<td>First GEC Historical Study</td>
<td>Second GEC Historical Study</td>
<td>be a Biological Science)</td>
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</tr>
<tr>
<td></td>
<td>First Additional Breadth course</td>
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<td>Elective</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Second Additional Breadth course</td>
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Appendix G. AMS Policy Statement on Bachelor of Science in Atmospheric Science

Bachelor's Degree in Atmospheric Science


1. Introduction
2. Attributes of bachelor's degree programs
3. Appendix A: Preparation for selected careers in atmospheric science
4. Appendix B: Federal civil service requirements for meteorologist positions
   (GS 1340, effective 1 March 1998)

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 hours² 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 radiation³;

- 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 experience⁴ 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 underrepresented 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.

d. 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.

e. 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
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,

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.