

## **Basic Program Information**

- (1) Proposing institution;** University of Kansas
- (2) Title of proposed program;** Atmospheric Science
- (3) Degree(s) to be offered;** PhD in Atmospheric Science
- (4) Anticipated date of implementation;** 1/1/2015
- (5) Responsible department(s) or unit(s);** Geography
- (6) Center for Education Statistics (CIP) code associated with the program;** 40.0401

## **Program Proposal Narrative**

### ***Is the program central to the mission of the institution?***

The University of Kansas is a major comprehensive research and teaching university that serves as a center for learning, scholarship, and creative endeavor. According to its Board of Regents-approved mission statement, the University is committed to offering the highest quality undergraduate, professional and graduate programs, comparable to the best obtainable anywhere in the nation. As the only AAU research university in the state, KU offers a broad array of advanced graduate study programs and fulfills its mission through faculty, academic and research programs of international distinction and outstanding libraries, teaching museums and information technology. These resources enrich the undergraduate experience and are essential for graduate-level education and research.

The Department of Geography wishes to institute a Doctor of Philosophy degree in Atmospheric Science to support the University's mission of offering a broad array of advanced graduate programs. One of the main missions of the Geography Department at KU is to provide instruction on environmental processes, on how anthropogenic actions affect the environment and on methods for detecting and documenting such processes. The atmosphere is a key component of the environment and affects human activities in a variety of ways. This influence is clearly seen in the research projects currently pursued by faculty in the Atmospheric Sciences program. For example, some of these research projects explore

- 1) The role of atmospheric variability on the development and decay of ice sheets.
- 2) The development of precipitating storms and the causes of small-scale variations in precipitation distribution.
- 3) Fundamental cloud and precipitation processes and their influence on climate and climate change.
- 4) Multiscale interactions between different components of the biosphere, specifically concentrating on land-atmosphere interactions and the resulting changes to the atmospheric boundary layer and the surface water budget.
- 5) Evaluating the influence of global-scale landcover changes and urban systems processes on climate and climate change

Environmental problems, especially those involving the atmosphere, are of increasing concern on the international, national and state levels. The recent controversies about coal-fueled power plants and renewable energy standards indicate the concerns about these issues in the state of Kansas. People with advanced training in atmospheric science are particularly important to the state of Kansas because of its strong aviation and agriculture industries, both of which are strongly influenced by weather and climate and water resource issues. Although the Atmospheric Science program has a vigorous undergraduate and masters program, some employment opportunities require a PhD.

The Atmospheric Sciences program is in the Department of Geography. Although Geography and Atmospheric Science have much in common, the current PhD in Geography does not meet the needs of Atmospheric Science students. The NSF-funded Center for the Remote Sensing of Ice Sheets needs students who are interested in researching atmospheric-related topics. As climate change becomes of increasing concern to human societies, the University of Kansas needs to support educational activities related to this problem, including the key field of Atmospheric Science and climate.

Impetus for this request include that both the Geography Departmental Advisory Board and the 2011-2012 external review panel of the Geography Department independently made recommendations to create a PhD program in Atmospheric Science. To maintain and expand the recent substantial growth in external research funding in the area of atmospheric and climate, a PhD program in Atmospheric Science is required. With this degree we will be able to attract students with the background to perform the advanced computer simulations and interpretation of research work that is required to be successful in completing the funded research we have already have and anticipate in the future. Presently, we have difficulty finding qualified Graduate Research Assistants (GRAs) to meet the demand originating from our existing external research grants. Hence, PhD students are absolutely vital to fulfilling the goals of our extramurally funded research projects, and the persistent lack of the PhD degree program seriously compromises our future funding possibilities.

The PhD degree in atmospheric science is especially critical to allowing the University of Kansas to become a full member of the University Corporation of Atmospheric Research (UCAR). KU currently has affiliate member status, however, becoming a full member will allow for better access to the shared National Center for Atmospheric Research (NCAR) computing (specifically the Weather Research Forecasting (WRF) and Community Earth System Model (CESM) simulation platforms), experimental and data resources provided through NCAR (e.g. research aircraft, global climate and weather data etc.). It will also allow for expansion of interactions with NCAR, an organization with which we currently have a number of funded research projects; and one where we anticipate significant future funding opportunities if we can meet the required personnel requirements (i.e. GRA and faculty time). A final need for

the resources (students and stature) provided by a PhD program is becoming apparent as our flux tower program, a “network of regional observation towers in Kansas” that integrates measurements of the exchange of carbon dioxide, water vapor, and energy between terrestrial ecosystems and the atmosphere, has received long-term funding in becoming part of the national/international flux tower networks (Ameriflux and Fluxnet).

***What is the student demand for the program?***

Atmospheric science is interesting to students with a variety of different backgrounds because atmospheric science integrates concepts from various disciplines. There is a nationwide interest in atmospheric problems. Students doing undergraduate degrees in physics, chemistry, engineering, mathematics and other earth sciences can enter the program. Students have expressed a strong desire for this program. In a recent survey of our 22 member senior class all those who were interested in doing a PhD were interested in a program at the University of Kansas. Several of our current MS students have expressed a desire to continue study for the PhD at the University of Kansas. Recruiting students for our MS program would be easier if we also had a PhD program. We have observed that some prospective students for our MS program in Atmospheric Science become less interested in the program when they realize the department does not also offer a PhD in Atmospheric Science.

***What is the demand for graduates in this program?***

The PhD degree is research oriented. Traditional employers include colleges and universities. Research facilities in Atmospheric Science are run by the National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA). Other national laboratories such as Lawrence Livermore, Los Alamos, and Oak Ridge hire people with PhD degrees in Atmospheric Science. In addition, several laboratories run by the military hire civilians with PhD degrees in Atmospheric Science. Concern about climate change has led to an increased need for people with a PhD degree in the environmental sciences including atmospheric science. Other federal employers include the EPA, FAA, and the Department of Agriculture. The armed forces will often send its officers to U.S. universities for graduate training in atmospheric science. People who have earned degrees in other physical sciences seek a graduate degree in Atmospheric Science to go into this line of work.

Environmental consulting in air pollution and hydrometeorology are also big employment fields for students studying atmospheric science. *US News and World Report* recently stated “Employment in this field is forecasted to increase faster than average. Job seekers will face competition for the best positions, and those with advanced degrees can expect more opportunities than those who only possess a bachelor’s degree”. The web site GACollege411 quotes Brent Yarnal of Penn State University as saying “There’s a very limited pool of people going into graduate school to specialize in climatology. We have more research assistantships and post-doctoral research fellowships than we have applicants to fill them, especially from here in North America.” The Occupational Outlook Handbook expects employment opportunities for atmospheric

scientists to increase at a rate of 11% per year. The *Wall Street Journal* estimated from the 2010 Census that the unemployment rate among atmospheric scientists was 1.6%, the second best of all scientific careers.

***What are the locational and comparative advantages of this program?***

The Atmospheric Sciences program at KU is unique in the state of Kansas, and the proposed PhD in Atmospheric Science does not exist at any other school in Kansas. Since the undergraduate and MS programs in Atmospheric Science is at the University of Kansas, it follows that is the appropriate place to locate a PhD program.

There are several other PhD programs in Atmospheric Science/Meteorology at schools in this region. They are:

- University of Oklahoma – This program is very large and of high quality. Admission to this program is very competitive and many students who have the ability to complete a PhD program cannot gain admission to it. The program does not, however, place much emphasis on air pollution meteorology, boundary layer meteorology or climatology, areas that are traditional strengths of the Atmospheric Sciences program at the University of Kansas. This issue is especially important as there are several employers in the Kansas City area who hire meteorologists to do air pollution consulting.
- University of Missouri – This program is very small with only four professors. It is almost exclusively focused on weather analysis and forecasting. It offers limited opportunities to Kansas students.
- St. Louis University – This program is of high quality and moderate size. Traditional strengths have been in weather analysis and forecasting but this program has expanded in recent years to include more climate and boundary-layer research. The university is affiliated with the Roman Catholic Church and some students, who are not Catholic, feel uncomfortable with the affiliation.
- Iowa State University – This program is of high quality and moderate size. It emphasizes weather analysis and forecasting but has small climate and boundary-layer research programs.
- University of Nebraska – This is a fairly small program focused on climate, especially with agricultural applications. There is a small weather analysis and forecasting research group.
- University of Colorado – This is a moderately large and high quality program focused primarily on theoretical aspects of atmospheric science. Its strengths are in dynamic and physical meteorology and atmospheric chemistry. There is no undergraduate program associated with this program, so KU will be competitive because it offers a full range of Atmospheric Science options given the strong reputation of our undergraduate program.

- Colorado State University – This program is very large and of high quality. Its strengths are in atmospheric radiation (including some work on climate change), mesoscale meteorology and atmospheric chemistry. Admission to this program is very competitive and many students who are capable of completing a PhD program cannot gain admission to it.

Although the region has a number of Atmospheric Science/Meteorology programs these programs are not able to admit all qualified students and therefore cannot meet the needs of some of our prospective students. In addition, some students want to earn a PhD in Atmospheric Science but cannot leave the northeast Kansas area. Also our specialized focus on climate and meteorology will distinguish our program from the other regional programs area that do not specialize in this area.

***Why should the program be located at this institution?***

This program will help broaden the ability of a number of engineering and science programs to measure and understand the interactions between atmospheric processes and such essential resources as water, air quality and the impacts of storms and climate change on society. Adding this program will increase and the research profile of the University of Kansas a Very High Research Activity (RU-VH) institution, an AAU member, and the leading comprehensive research institution in the State of Kansas. This program would benefit the state of Kansas, as no other institution in the state offers a similar program, and KU already offers undergraduate and Master's degrees in this field, making a PhD program a logical extension at this institution. The faculty associate with this program already offer expertise to other state Universities and institutions (e.g. the Kansas Water Office).

***What are the characteristics of the students who will participate in this proposed program?***

Students for this proposed program could come from a variety of different backgrounds. One would be students from the state of Kansas. These students have earned an undergraduate degree in either atmospheric science or another physical science and now want to earn a graduate degree in atmospheric science. Students from other backgrounds who have the necessary prerequisite courses may also apply. People who have moved to Kansas and are employed and now want to earn a graduate degree in atmospheric science are another source of students. Many of these students could be part time. We also anticipate drawing students from other states, especially states which do not have graduate programs in atmospheric science. We also expect that our unique combination of atmospheric and climate sciences will draw on a national pool of students that will not be satisfied with traditional PhD programs that are more narrowly focused on forecasting and weather phenomena. In addition, the program could attract international students as the demand for graduate study in the U.S. is high in atmospheric and climate science.

Entering students are expected to have a M.S. degree in atmospheric science or in another physical science, mathematics or engineering. Applicants should have a minimum Grade Point Average (GPA) of 3.0 on a 4.0 scale. Applicants with a GPA of less than 3.0 may be considered for admission on a probationary or provisional status. Entering students will be expected to have studied mathematics, including vector calculus and ordinary differential equations. They should also have taken the equivalent of at least 2 semesters of calculus-based physics and one of chemistry. Graduate Record Examination scores (verbal, quantitative and analytical) are required of all applicants. If the student needs to take formal coursework to make up a deficiency, these credit hours will not count toward the PhD. A deficiency may be removed by 1) passing the specified course with at least a "C," 2) auditing the course and receiving a letter from the instructor indicating that the course requirements have been met, or 3) passing a written and/or oral examination comparable to the final exam. Deficiencies will be specified at matriculation and must be completed before the PhD oral examination is taken.

We expect that most students in this program will be teaching assistants or research assistants for at least part of their program. Teaching assistants will learn about presenting atmospheric science material to undergraduates. Research assistants will work with faculty, other students and technicians on research projects.

The program will be flexible and thus amenable to part time study and we expect that some people who are interested in the degree program will want to continue to work full time.

### ***What is the curriculum of the proposed program?***

We propose to develop a PhD degree in Atmospheric Science. The program would require a minimum of sixty hours: thirty hours of course work and thirty hours of dissertation research. This number of credit hours is consistent with the PhD in Geography. Students must take all the courses required for the Masters degree, namely ATMO 710, ATMO 720 and GEOG 716 or equivalent course work at another university. Up to 12 hours of independent study may be used towards course work. The faculty consider it to be very important that students acquire a research skill in mathematics, statistics or applied science. The Research Skill and Responsible Scholarship (RSTS) requirement will be met by 6 credits at the 500 level or above in mathematics and/or engineering. Alternatively, 6 credits at the 500 level or above in a related discipline which are approved by the student's graduate committee may also be used for the RSS requirement. The courses for the RSRS requirement must be taken during the PhD program. Students must participate in the existing Geography Department ethical scholarship program.

Upon a student's admission to the department, the Graduate Studies Committee will appoint an advisor. Early in the first semester (preferably in the first week of classes), the student should meet with this advisor to outline a tentative program of coursework for the degree. Such programs should be solidified by the time of enrollment for the second semester and submitted to the GSC for approval. The student and advisor

then continue to discuss and update programs each semester including all elective coursework, bearing in mind that any substantive changes must be approved by the GSC. The program is designed to be very flexible to meet the individual needs of students and to meet the diverse employment opportunities that this program will serve. Electives are selected with approval of the committee and are tailored to fit the needs of the individual student (e.g. oriented to a subfield in meteorology, climatology, or other specializations). While exact course selection will depend on their background, typically students would select the majority of courses from the following suite of courses:

ATMO 710 Atmospheric Dynamics, ATMO 720 Atmospheric Modeling. Some incoming students may have some of this background  
ATMO 731 Advanced Topics in Atmospheric Science. This is a topics course that has, in the past covered urban climates, cloud dynamics, synoptic meteorology, and surface-atmosphere interactions. It can be repeated for credit.  
MATH 647 Applied Partial Differential Equations, MATH 781 Numerical Analysis  
GEOG 558 Intermediate Geographical Information Systems, GEOG 758 Geographic Information Science, GEOG 716 Advanced Geostatistics, GEOG 538 Environmental Soil Physics and Chemistry, GEOG 756 Energy problems and the economic-physical environment  
BIOL 513 Principles of Ecology, BIOL 570 Biostatistics, BIOL 594 Forest Ecosystems, BIOL 841 Biometry  
CE 725 Multivariate Statistical Methods, CE 730 Intermediate Fluid Mechanics, CE 751 Watershed Hydrology, CE 779 Water Quality

3 credits independent study

Program sheets are available in the department office and must be filed before the oral examination can be scheduled. The student will have a thesis committee consisting of at least 5 faculty members. At least four of these faculty members must regularly teach in the atmospheric sciences program. One of the faculty members on the committee must be from outside the Geography department. All candidates must pass a comprehensive written and oral examinations and must submit an acceptable dissertation. The dissertation will also be defended in a public presentation.

### ***What is the quality of the faculty?***

Atmospheric Science has broad applications to many fields. Thus, a number of KU faculty members in departments outside of Geography have expertise in some aspects of Atmospheric and Climate Science. These faculty members will serve on graduate committees and sometimes offer courses related to Atmospheric Science.

The following are faculty in the department of Geography who will participate in the program as core faculty; with the percentage of their total time they expect to devote to the PhD program. All faculty involved with the program have Ph.D. degrees

David Braaten, Professor  
Nathaniel Brunsell, Associate Professor  
Johannes Feddema, Professor  
William Johnson, Professor  
David Mechem, Associate Professor  
David Rahn, Assistant Professor  
Donna Tucker, Associate Professor  
Cornelius van der Veen, Professor

All the faculty listed above, except Prof. Johnson, are also involved with the undergraduate and MS programs in atmospheric science. Prof. Feddema, Prof. Johnson and Prof. van der Veen are also involved in the undergraduate and graduate programs in Geography. There are also a number of other faculty (there are 12 additional faculty) in the Geography department that will provide additional support; particularly faculty working in the areas of remote sensing, and Spatial analysis and GIS applications. Although new faculty would be desirable, we are not proposing any at this time.

Faculty members outside of the department of Geography who will participate in this program are:

Sharon Billings, Associate Professor, Ecology and Evolutionary Biology, 5%  
David Fowle, Associate Professor, Geology, 5%  
Leigh Sterns, Assistant Professor, Geology, 5%  
Dennis Lane, Professor, Civil/Environ/Arch Engineering, 5%  
Belinda Sturm, Assistant Professor, Civil/Environ/Arch Engineering, 5%  
C. Bryan Young, Associate Professor, Civil/Environ/Arch Engineering 5%  
Zongquan Zheng, Professor, Aerospace Engineering, 5%

***How many graduate assistants will serve the program?***

We have 5 graduate teaching assistants for this program and the MS program, combined, meaning there are no requests for new GTA lines. These teaching assistants will teach laboratory sections in the ATMO 105 course, Introductory Meteorology, and the online versions of ATMO 105 and ATMO 210 as well as assisting with other undergraduate Atmospheric Sciences courses. With the increased opportunities we anticipate expanding our undergraduate offerings to include more laboratory sections (e.g. especially with introductory climate and land surface courses (e.g. ATMO 321 and ATMO 521), which we expect to translate into additional GTA position in the future.

We also expect a number of students will be supported by research assistantships rather than teaching assistantships. The number of these students will vary depending on support available from the research programs of the individual faculty members, but we expect a minimum of about 6-8 students in the PhD program will be supported under research assistantships at a time and paid from research funding (approximately \$20,000 per GRA or about \$120,000-\$160,000 as available from external grants).



## **Academic Support**

### ***What are the academic support services for this program?***

The main support services needed by this program are computer technicians and library materials and services. The computers themselves will be described in the facilities section of this proposal.

### ***What are the advising support services for this program?***

Upon a student's admission to the department, the Graduate Studies Committee (GSC) will appoint a faculty advisor. The student will meet at least once a semester with this advisor to outline coursework for the degree and review progress. A degree program plan is submitted to the GSC for approval and any substantive changes must be approved by the GSC.

### ***What new library materials and other forms of academic support are required beyond normal additions?***

The library already has subscriptions to online or paper copies of the key journals in this field. Included are such journals as *Journal of the Atmospheric Sciences*, *Journal of Climate*, *Journal of Applied Meteorology and Climatology*, *Monthly Weather Review*, *Weather and Forecasting*, *Journal of Hydrometeorology*, *Journal of Geophysical Research*, *Quarterly Journal of the Royal Meteorological Society*, *Atmospheric Environment*, *Agricultural and Forest Meteorology*, *Boundary Layer Meteorology*, and *Tellus*. In addition, the library has an online subscription to *Meteorological and Geoastrophysical Abstracts*. The library also has a large variety of books on atmospheric science subjects. Thus, we feel that present library resources and normal additions will be sufficient to support this program and no additional forms of academic support are required. .

### ***What new supporting staff will be required beyond normal additions?***

The department of geography has two full time office staff members and one part time office staff member. These staff members already support the Masters degrees in geography and atmospheric science as well as the PhD degree in geography and we feel they are able to handle the additional workload the PhD degree in atmospheric science will require.

The department of geography has access to 2 full-time computer system administrators. With both of these system administrators, the department has sufficient staff members to support the computational requirements of the department, including this proposed PhD degree.

### ***What are the anticipated facilities and equipment requirements?***

The current space allocated to Geography is sufficient and no additional resources are requested for facilities or equipment to support the new degree.

The following field equipment is available for student research:

- 4 eddy covariance stations each with triaxial sonic anemometers, high frequency temperature measurements and an infrared gas analyzer for water vapor and carbon fluxes with appropriate data loggers
- To go with each of the eddy covariance stations are directional net radiometers, solar and PAR sensors for soil moisture, soil temperature and soil heat fluxes.
- 1 large aperture scintillometer
- 1 radiosonde system for measuring atmospheric profiles of temperature, humidity and winds
- 3 sets of Campbell Scientific data loggers with temperature, humidity, wind, solar radiation and snow height sensors
- Optical Particle Counter
- Hot wire anemometry system

The following computer resources are available:

- A Linux computing cluster and substantial disk storage for performing modeling simulations and analyzing multi-terabyte meteorological datasets. The current cluster, built by Aspen Systems, employs the Intel Xeon E5520 2.26 GHz quad-core (Nehalem) processors for a total of 152 computational cores. Total system memory is 152 GB, and the head node includes 6 TB of local disk. The interconnect between nodes and to the campus backbone is gigabit ethernet. In April 2013, the cluster will be upgraded using two Supermicro 2U twin/twin chassis with four integrated dual-socket motherboards (four independent nodes per chassis). Each node will contain two Intel E5-2650, 2.0 GHz, 8-core Sandy Bridge microprocessors for a total of 128 computational cores. The interconnect will be upgraded to Infiniband, which is important for running meteorological models. An adjacent RAID disk server provides an additional 55 TB of storage and an additional computational platform for analysis. Total disk was upgraded in April 2013 by an additional 100 TB of storage. The upgrade also included a tape archive backup system for redundancy. The computing facilities include all the software, compilers, and analysis tools needed for model development and post processing analysis.
- Students working on CReSIS projects have access to a Linux cluster (128 CPU cores and 128GB RAM) running the Mathworks Distributed Computing Engine with 800 TB hard drive space.
- The PhD program in atmospheric science will use the instructional facilities of the department of geography. One large room (the Meteorology and Climate Hub, MACH), is a computer resource center specifically for atmospheric science students. The MACH also has facilities for student presentations to small groups.
- The MACH has the following computer equipment. This equipment is normally replaced with new equipment every 3-4 years: 12 Dell Optiplex computers 10

- running Linux and 2 running Windows. These computers have Intel Core 2 quad processors, 4 GB RAM, 500 GB hard drive.
- Xerox Phaser 8560 Color Printer
- Hewlett Packard Black and White Laser Jet Printer
- Additional computers: 1 Mac Pro (2.4 GHz Xenon – 8 cores), 1 Dell Precision Xenon 4 cores, 12 GB RAM, running Linux, 6 Apple iMacs (Intel Core i5 processors), 2 Dell Optiplex 960 running Linux, 2 Intel Core 2 computers with 4 GB RAM, and 250 GB hard drives, dual boot Windows/Linux.
- Students and faculty working on projects affiliated with NCAR will have access to their computational resources (<http://ncar.ucar.edu/community-resources/computational-resources>).

***What is the program review process or what evaluation methods will be used to review the program?***

The College of Liberal Arts and Sciences conducts departmental reviews that meet KBOR program review requirements. The department of Geography was reviewed in 2011-2012 is scheduled for and every 7-8 years thereafter. The review would include both self-study and external review components. The external review which was done in 2011-2012 recommended that the department start a PhD program in atmospheric science. This degree program would be reviewed under this process. Curricula for department courses are reviewed each year during the faculty evaluation process to ensure that they are appropriate for the courses being taught. The department meets annually to decide which students to award Graduate Teaching Assistants to for the following year. At this meeting overall graduate funding is reviewed as the department examines which students have fellowships from KU, which are supported as Graduate Research Assistants, and which have other types of funding.

***What student learning outcomes measures will be used to assess the program's effectiveness?***

A number of measures of student learning will be used. Student grades in graduate level courses reflect student learning. Quality of student theses and oral presentations of the research show how the student has applied what was learned. Publication of student research in peer reviewed journals will confirm research quality. Quality of student presentations at professional conferences will make the program's effectiveness clear. We will also examine how long it takes students to finish their degrees. Students would normally finish their degrees in four years of full time study but we do expect some part time students in this program to take longer.

***What are the institution's plans regarding program accreditation?***

No professional organization accredits masters programs in atmospheric science. There are no recommendations published by a professional society for minimum requirements for a PhD in atmospheric science.

**Academic Program Proposal**  
University of Kansas – Lawrence

<b><u>Criteria</u></b>	<b><u>Program Summary</u></b>
1. Program Identification	PhD in Atmospheric Science CIP Code: 40.0401
2. Academic Unit	College of Liberal Arts and Sciences Department of Geography
3. Program Description	<p>Atmospheric Science is a discipline which is of key importance for a number of environmental issues, such as air pollution, that are of increasing concern on the international, national and state levels. The atmosphere is a key component of the environment and affects human activities in a variety of ways.</p> <p>Atmospheric Science is central to the current concerns scientists have about global climate issues. Weather and climate change analysis and forecasting are critically important to Kansas industries such as agriculture and aviation, both of which are strongly influenced by weather, climate, and water resource issues. Research and even routine work in these areas increasingly requires people with graduate degrees in Atmospheric Science.</p> <p>This program will help broaden the ability of a number of engineering and science programs to measure and understand the interactions between atmospheric processes and such essential resources as water, air quality and the impacts of storms and climate change on society.</p>
4. Demand/Need for the Program	<p>Concerns about climate have led to an increased need for people with a PhD degree in the environmental sciences including atmospheric science. Since the PhD is research oriented, traditional employers include colleges and universities. However, students have a wide range of employment opportunities which include atmospheric research centers, laboratories that are run by the military but hire civilians, federal agencies like the FAA and Dept. of Agriculture, and environmental consulting firms. The Occupational Outlook Handbook expects employment opportunities for atmospheric scientists to increase at a rate of 11% per year.</p> <p>The PhD program was recommended by the Departmental Advisory Board, and was a suggested outcome of the 2010 external review of the Geography Department. Undergraduate and masters students have expressed a strong desire for this program. A PhD program would also enhance recruitment to the masters program.</p>

<p>5. Comparative /Locational Advantage</p>	<p>The University of Kansas offers the only Bachelor's and Masters degree programs in Atmospheric Science in Kansas. Other schools in the region that have PhD programs in Atmospheric Science/Meteorology include University of Oklahoma, Iowa State University, University of Missouri, St. Louis University, University of Nebraska, University of Colorado and Colorado State University.</p> <p>Although the region has several Atmospheric Science/ Meteorology programs these programs are not able to admit all qualified students and therefore cannot meet the needs of some of our prospective students. In addition, some students want to earn a PhD in Atmospheric Science but cannot leave the northeast Kansas area. Also our specialized focus on climate and meteorology will distinguish our program from the other regional programs area that do not specialize in this area.</p>
<p>6. Curriculum</p>	<p>The program will require a minimum of sixty hours: 30 hours of course work and 30 hours of dissertation research. Students must take all the courses required for the Masters degree, namely ATMO 710, ATMO 720 and GEOG 716 or equivalent course work at another university. Up to 12 hours of independent study may be used towards course work. The Research Skills and Responsible Scholarship (RSRS) requirement will be met by 6 credits at the 500 level or above in mathematics and/or engineering. Alternatively, 6 credits at the 500 level or above in a related discipline which are approved by the student's graduate committee may also be used for the RSRS requirement. The courses for the RSRS requirement must be taken during the PhD program. Students must participate in the existing Geography Department ethical scholarship program. The student must submit a dissertation approved by his/her graduate committee.</p>

<p>7. Faculty Profile</p>	<p>The following faculty in the department of Geography will comprise the core faculty of the program:</p> <p><b>David Braaten</b> Professor  <b>Nathaniel Brunsell</b> Associate Professor  <b>Johannes Feddema</b> Professor  <b>William Johnson</b>, Professor,  <b>David Mechem</b> ,Assistant Professor  <b>David Rahn</b>, Assistant Professor  <b>Donna Tucker</b> Associate Professor  <b>Cornelis Van der Veen</b>, Professor</p> <p>In addition there are 12 additional faculty in the Geography department. We expect significant support from the spatial technology faculty for example, Dr. Egbert will provide support for remote sensing and Dr. Li will provide support related to geographic information tools and resources.</p> <p>Because of the interdisciplinary nature of the program, faculty in other departments who will participate in this program include:</p> <p>Sharon Billings, Associate Professor, <i>Ecology and Evolutionary Biology</i>  David Fowle, Associate Professor, <i>Geology</i>  Leigh Sterns, Assistant Professor, <i>Geology</i>  Dennis Lane, Professor, <i>Civil/Environ/Arch Engineering</i>  Belinda Sturm, Assistant Professor, <i>Civil/Environ/Arch Engineering</i>  C. Bryan Young, <i>Civil/Environ/Arch Engineering</i>  Zongquan Zheng, <i>Aerospace Engineering</i></p>
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8. Student Profile	<p>Entering students are expected to have a M.S. degree in atmospheric science or the equivalent in another physical science, mathematics or engineering. Applicants should have a minimum Grade Point Average (GPA) of 3.0 on a 4.0 scale. Applicants with a GPA of less than 3.0 may be considered for admission on a probationary or provisional status. Entering students whose degree is not in atmospheric science may be required to take additional coursework. Graduate Record Examination scores (verbal, quantitative and analytical) are required of all applicants. If the student needs to take formal coursework to make up a deficiency, these credit hours will not count toward the PhD. A deficiency may be removed by 1) passing the specified course with at least a "C," 2) auditing the course and receiving a letter from the instructor indicating that the course requirements have been met, or 3) passing a written and/or oral examination comparable to the final exam. Deficiencies will be specified at matriculation and must be completed before the PhD oral examination is taken.</p>
9. Academic Support	<p>The geography department has computer system administrators and office staff to support the program. The library has sufficient resources to support the program.</p>
10. Facilities and Equipment	<p>Anticipated facilities for the proposed program already exist. The program does not require a new building; it will share classrooms, lecture halls, laboratories, computer rooms and libraries as do other programs in the College of Liberal Arts and Sciences at the University of Kansas.</p> <p>The program will require no new equipment. It will utilize existing office and electronic equipment at the Department of Geography.</p>
11. Program Review, Assessment, Accreditation	<p>The College of Liberal Arts and Sciences conducts departmental reviews. Curricula for department courses are reviewed each year during the faculty evaluation process to ensure that they are appropriate for the courses being taught. No professional organization accredits doctoral programs in atmospheric science however, the program will be reviewed as part of the department of Geography reviews conducted as part of the KBOR program review cycle.</p>
12. Costs, Financing	<p>No additional resources are required to support the program.</p>

# CURRICULUM OUTLINE

## University of Kansas

**I. Identify the new degree:** PhD Atmospheric Science

**II. Provide courses required for each student in the major:**

	<b>Course Name &amp; Number</b>	<b>Credit Hours</b>
<b>Core Courses</b>	ATMO 710 Atmospheric Dynamics	___3___
	ATMO 720 Atmospheric Modeling	___3___
	GEOG 716 Advanced Geostatistics	___3___
	500 level and above courses in mathematics, engineering, or other research skill courses approved by student's committee	___6___
<b>Electives</b>	Courses to bring total coursework to 30 credits	__15-24__
	Electives are selected with approval of the committee and are tailored to fit the needs of the individual student (e.g. oriented to a subfield in meteorology, climatology, or other specializations)	
	Sample Courses include:	
	ATMO 731 Advanced Topics in Atmospheric Science. This course can be repeated for credit.	
	MATH 647 Applied Partial Differential Equations	
	MATH 781 Numerical Analysis	
	GEOG 558 Intermediate Geographical Information Systems	
	GEOG 758 Geographic Information Science	
	GEOG 716 Advanced Geostatistics	
	GEOG 538 Environmental Soil Physics and Chemistry	
	GEOG 756 Energy problems and the economic-physical environment	
	BIOL 513 Principles of Ecology	
	BIOL 570 Biostatistics	
	BIOL 594 Forest Ecosystems	
	BIOL 841 Biometry	
	CE 725 Multivariate Statistical Methods	
	CE 730 Intermediate Fluid Mechanics	
	CE 751 Watershed Hydrology	
	CE 779 Water Quality	
<b>Research</b>	Dissertation Research	___30___
	<b>Total</b>	__60__



2014

## Fiscal Summary for the Proposed Academic Program

Institution: University of Kansas - Lawrence

Proposed Program: PhD Atmospheric Science

### Part I. Anticipated Enrollment

	Implementation Year		Year 2		Year 3	
	Full-Time	Part-Time	Full-Time	Part-Time	Full-Time	Part-Time
A. Headcount	2	1	5	1	8	1
B. Total SCH taken by all students in the program	30		66		100	

### Part II. Program Cost Projection

A. In the implementation year, list all identifiable **General Use** costs to the academic unit(s) and how they will be funded. In subsequent years, please include **only** the additional amount budgeted.

	Implementation Year	Year 2	Year 3
<u>Base Budget</u>			
Salaries	\$ -	\$ -	\$ -
OOE	-	-	-
Total	\$ -	\$ -	\$ -

Indicate source and amount of funds if **other than** internal reallocation:

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