COLLEGE OF
**ENGINEERING &
APPLIED SCIENCE**

UNIVERSITY OF WYOMING

WORKING FOR WYOMING & THE WORLD

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Date: 18 August 2016

To: Kate Miller, Provost and Vice President of Academic Affairs
Anne Alexander, Associate Vice President of Academic Affairs

From: Michael V. Pishko
Dean, College of Engineering & Applied Science

RE: Atmospheric Science Program Review

As per instructions from Academic Affairs, the Atmospheric Science M.S. and Ph.D. programs have been reviewed. Pursuant to UW guidelines for program review, I recommend the programs mentioned above be retained for further review with the following criteria:

- The Department of Atmospheric Science show consistent increase in graduate student enrollment in these programs and increases in student credit hours taught by faculty within the department.
- The flight center separate operations of the research aircraft from the UW transportation aircraft, and develop and implement a MOU to permit synergies and cost sharing between research and transportation aircraft flight operations and maintenance.
- The Department develop plans for existing research aircraft refurbishment or new aircraft acquisition in a manner that does not require state support to implement.
- The Department continue to implement a research strategy that does not require direct state support with the exception of occasional bridge funding.

Additional review should occur at the beginning of FY19, coinciding with renewal of the National Science Foundation cooperative agreement for operations of the research aircraft flight center. This department and its flight center are a highly productive and internationally recognized research operation and this merits retention and further evaluation of the program.

cc: Thomas Parish, Steve Barrett, Megan Barber, File

Academic Program Review
Report Template
University of Wyoming
Office of Academic Affairs
March 2016

(adapted from SDSU)

Deans and Directors who administer an authorized major or course of study approved by action of the Board of Trustees will be responsible for conducting program reviews. Four key elements should be addressed in each academic program review: (1) Program Demand, (2) Program Quality, (3) Mission Centrality, and (4) Cost.

For each program that is reviewed, a recommendation will be made by the Academic Dean to the Vice President of Academic Affairs.

Instructions: *Please provide the following information:*

Title of Program/Specialization: **Atmospheric Science**
Indicate whether undergraduate or graduate program/specialization: **M.S. Program**
Department and College: **College of Engineering and Applied Science**
Department Head Name and contact information (phone, email): Thomas R. Parish (parish@uwyo.edu, 766-5153)

Part 1 – Program Review

Instructions: *Please answer each of the following questions. Items listed under each question have been provided to help guide your response. If an item is not applicable, simply indicate "N/A".*

1. **Program Demand*****:**

(*Note: If degrees granted exceeds cutoff, delay review until next round*.)

a. Number of graduates over 5-year period:

Five Year Period: Fall 2011 – Summer 2016

24 M.S. degrees granted – Plan A only (List of students is attached as Appendix i)

b. Enrollment in major/specialization over 5-year period: *(Fall 2011 – Summer 2016) incoming M.S. students - 36*

* Cutoffs for "Low Demand" Designation -- *Degrees Granted*

- Bachelor's Programs: Average – 5 per year; 5-year total: 25
- Master's Programs: Average – 3 per year; 5-year total: 15
- Ph.D. Programs: Average – 1 per year; 5-year total: 5

(See APPENDIX A for the types of programs that will be excluded from review.)

2. **Program Quality: Is the program of high quality?**
    a. Program accreditation – *N/A*
        i. For programs currently accredited include:
            1. Name of accrediting body/organization
            2. Date most recently accredited
            3. Next reaccreditation date
            4. List recommendations from most recent visit and progress to date.
        ii. For programs seeking accreditation include:
            1. Name of accrediting body/organization
            2. Timeline for seeking accreditation
        iii. For all other programs include:
            1. Date of most recent Academic Program Review (APR)
               None in the past 10 years
            2. List of recommendations from the most recent APR and progress to date.
               N/A

        (Note: For first-time reviews, include N/A in response.)

    b. Credentials of faculty
        i. Include a list of all faculty by name, highest degree and discipline of highest degree.

        Jeffrey R. French, Ph.D., Atmospheric Science, University of Wyoming, 1998 (Assistant Professor).
        Bart Geerts, Ph.D., Atmospheric Science, University of Washington, 1990 (Professor).
        Robert D. Kelly, Ph. D., Atmospheric Science, University of Chicago, 1982 (Professor).
        Zachary J. Lebo, Ph.D., Environmental Science and Engineering, California Institute of Technology, 2012 (Assistant Professor).
        Xiaohong Liu, Ph.D., Atmospheric Science, Nanjing University, P.R. China, 1992 (Professor, Wyoming Excellence Chair in Climate Science).
        Shane M. Murphy, Ph.D., Chemical Engineering, California Institute of Technology, 2009 (Assistant Professor).
        Thomas R. Parish, Ph.D., Meteorology, University of Wisconsin-Madison, 1980 (Professor).
        Jefferson R. Snider, Ph.D., Atmospheric Science, University of Wyoming, 1988 (Professor).
        Zhien Wang, Ph.D., Atmospheric Science, University of Utah, 2000 (Professor).

        Recent retirees:

        Terry Deshler, Ph.D., Physics, University of Wyoming, 1982 (retired May 2014).

Derek C. Montague, Ph.D., University of Southampton, UK, 1967 (retired May 2015).
Alfred R. Rodi, Ph.D., Atmospheric Science, University of Wyoming, 1981 (retired June 2016).

ii. Also, include a breakdown by gender and ethnicity.

9 males; 2 Asian, 7 Not Hispanic or Latino

iii. Grants awarded to academic personnel: Previous 5 years

Note: Only funded proposals obtained through peer-review process from external agencies listed:

Five Year (2011-2016) Summary: ~59 grants acquired, ~$23M in external funding

Deshler:
Balloon measurements of the Asian tropopause Aerosol Layer (BATAL) 2015, NASA, 6/15-12/15, $99K, PI
The KlAsh campaign - A Rapid Response for Balloon Measurements of the Mt. Kelud Volcanic Plume, NASA, 5/14-6/14, $104K, co-PI
In situ measurements of stratospheric aerosol size distributions and their use in a new aerosol surface area climatology, NSF, 9/10-9/16, $1.053M, PI

French:
SNOWIE: Seeded and Natural Orographic Wintertime clouds – the Idaho Experiment, NSF-AGS, 9/16-9/18, $797K, PI
Wyoming King Air as a National Facility, NSF-AGS, 6/14-5/19, $9.4M, 1 of 3 PIs
REU Supplement to Wyoming King Air as a National Facility, NSF-AGS, 5/15-6/15, 7.2K, PI
The Convection Precipitation Experiment – Microphysical and Entrainment Dependencies, NSF-AGS, 1/13-12/16, 733K, co-PI

Geerts:
Dynamical processes of orographic cumuli II, NSF-ATM, 10/09-9/13, $476K, PI
Climate simulations of seasonal precipitation and snow accumulation patterns in the NC region, North-Central Climate Science Consortium, 10/12-9/13, $164K, co-PI
The cloud microphysical effects of ground-based glaciogenic seeding of orographic clouds: new observational and modeling tools to study an old problem, NSF-AGS, 8/11-7/16, $569K, PI

Collaborative research: The kinematics, microphysics and dynamics of long-fetch lake-effect systems in OWLeS, NSF-AGS, 8/13-6/16, $474, PI

Research Capacity Building using a new Dual-frequency Airborne Radar System in support of NASA GPM and ACE Validation Experiments, NASA-EPSCoR, 9/13-8/16, $750K, PI

PECAN (Plains Elevated Convection At Night): large campaign request (Geerts is lead on the Experimental Design Overview), NSF-AGS, 7/13-7/15, $15K,

Airborne measurements of the nocturnal low-level jet and wave disturbances in the stable boundary layer in PECAN, NSF-AGS, 1/15-12/17, $750K, 1 of 3 PIs

SNOWIE: Seeded and Natural Orographic Wintertime clouds – the Idaho Experiment, NSF-AGS, 9/16-9/18, $797K, co-PI

Liu (since arrival in 2013):

Constraining the Modeling of Dust Aerosol and Climate Impacts Using CALIPSO, CloudSat, and Other A-Train Satellite Measurements, NASA CloudSat and CALIPSO, 2/16-2/19, $450K, PI

Use of remote sensing and in-situ observations to develop and evaluate improved representations of convection and clouds for the ACME model, DOE-OBER, 08/16-07/19, $375K, PI

Improving Predictability of Mixed-Phase Clouds and Aerosol Interactions in the Community Earth System Model (CESM) with ARM Measurements, DOE-OBER, 7/15-7/18, $584K, PI

Wildfires and Regional Climate Variability: Mechanisms, Modeling and Prediction, DOE-OBER, 5/13-4/17, $628K, PI

Developing and Evaluating an Advanced Aerosol Module in GEOS-5 for Data Assimilation and Climate Studies, NASA, 1/13-12/16, $578K, PI

Development of Modal Aerosol Module in CAM5 for Biogeochemical Cycles, DOE-OBER, 4/14-4/16, $104K, PI

Further Enhancement of the Cloud Prediction Capabilities of the GEOS-5 AGCM for Radiative and Aerosol Indirect Effect Studies, NASA, 8/13-8/17, $72K, PI

Interplay between black and brown carbon from biomass burning and climate, EPA, 2/16-2/19, $350K, Co-PI (Shane Murphy, PI)

Murphy:

Interplay between black and brown carbon from biomass burning and climate, EPA STAR, 2/16-2/19, $350K, PI

Reconciling top-down and bottom-up greenhouse gas and air pollutant emission estimates from unconventional gas development, DOE, 9/14-9/16, $142K, co-PI

Quantification of Methane and Volatile Organic Compound (VOC) Emissions in the UGR Basin, Clean Air Task Force, $75K, co-PI.

Participation in Flame-IV: Understanding Aerosol Absorption in Biomass Burning Plumes Through Measurements of Single-Particle SSA, Coatings, and Brown Carbon, NSF, 10-12-10/14, $239K, PI

Development of new particle size spectrometer for rugged deployments in the Antarctic, tropics and mid-latitudes: Measurements from the surface to the stratosphere, NSF, 6/12-/15, $578K, co-PI

Measurements of Aerosol Chemistry during Wintertime High-Ozone Events, NSF, 1/12-11/12, $29K, PI

Parish:

Lidar and Modeling Applications from the PreAMBLE Dataset, NSF-AGS, 2/15-1/17, $175K, PI

Airborne measurements of the nocturnal low-level jet and wave disturbances in the stable boundary layer in PECAN, NSF-AGS, 1/15-12/17, $750K, 1 of 3 PIs

Precision Atmospheric Marine Boundary Layer Experiment (PreAMBLE), 5/11-5/14, $362K, PI.

Rodi:

Wyoming King Air as a National Facility, NSF-AGS, 6/14-5/19, $9.4M, Lead PI

Snider:

Instrumentation for Improved Precipitation Measurement in Wintertime Snowstorms, USGS and WWDC, 3/11-3/13, $71K, PI

EAGER: Collaborative Research: Chilean Coastal Orographic Precipitation Experiment Pilot Project (CCOPE-2015), NSF-AGS, 4/15-4/17, $51K, co-PI

Exploiting synergies between remote sensing and in situ measurements during ICE-T to better understand ice generation in tropical clouds, NSF, 12/10-11/14, $538K, co-PI

Wang:

Developing New Airborne Cloud, Aerosol and Water Vapor Observation Capabilities by Synergizing Remote Sensors and in Situ Probes on the University of Wyoming King Air, NSF-CAREER, 5/07-4/13, $587K, PI

Study Global Mixed-phase Cloud Properties by Combining CloudSat Radar, CALIPSO Lidar, and MODIS Measurements, NASA, 9/10-12/13, $518K, PI

Collaborative Research: Colorado Airborne Multi-Phase Cloud Study (CAMPS), NSF, 5/10-4/14, $179K, PI

Wyoming King Air as a National Facility, NSF-AGS, 6/14-5/19, $9.4M, 1 of 3 PIs

Exploiting synergies between remote sensing and in situ measurements during ICE-T to better understand ice generation in tropical clouds, NSF, 12/10-11/14, $538K, co-PI

CloudSat Level 2 Radar-only (2B-CLDCLASS) and Combined Radar-Lidar (2B-CLDCLASS-LIDAR) Cloud Scenario Classification Standard Product Improvement and Validation and the Enhanced Ice Microphysical Product Development., NASA-JPL, 4/05-9/15, $1.46M, PI

CloudSat Level 2 Radar-only (2B-CLDCLASS) and Combined Radar-Lidar (2B-CLDCLASS-LIDAR) Cloud Scenario Classification Standard Product Improvement and Validation and the Enhanced Ice Microphysical Product Development, NASA-JPL, 10/15-9/16, $150K, PI

Airborne measurements of the nocturnal low-level jet and wave disturbances in the stable boundary layer in PECAN, NSF-AGS, 1/15-12/17, $750K, 1 of 3 PIs

Improving Mixed-phase Cloud Parameterization in Climate Model with the ACRF Measurements, DOE, 9/11-8/16, $538K, PI

Research Capacity Building using a new Dual-frequency Airborne Radar System in support of NASA GPM and ACE Ground Validation Experiments, NASA-EPSCoR, 9/13-8/16, $750K, co-PI

Mixed-phase cloud property and process study with CloudSat, CALIPSO and other A-train measurements, NASA, 8/13-8/16, $521K, PI

Development of a Multi-function Airborne Raman Lidar (MARLi) for Atmospheric Process Studies, NSF-MRI, 9/13-8/16, $1.72M, PI

Improving Predictability of Mixed-Phase Clouds and Aerosol Interactions in the Community Earth System Model (CESM) with ARM Measurements, DOE, 6/15-5/18, $560K, co-PI

iv. Grants submitted by academic personnel: Previous 5 years

In addition to the successful proposals listed above, current faculty have submitted to the following external agencies proposals that were unsuccessful:

DOE – 6
NASA – 4
NOAA – 2
NSF - 14
UAE - 2

v. Publications/presentations by academic personnel

Note: Only refereed publications listed

Five Year (2012-2016) Summary ~175 refereed publications

(Detailed list of faculty refereed publications is attached Appendix ii)

vi. National/international awards

Xiaohong Liu named to the list "Highly Cited Researchers" by Thomson-Reuters, 2014; 2015

vii. Other

University of Wyoming Technology Transfer

Spin Off Company developed: Alpenglow Instruments. DOE SBIR grant received. Atmospheric Science personnel include Perry Wechsler, Zhien Wang, Nick Mahon and Dave Leon.

The Atmospheric Science Department has long been a national and international leader in the development, integration and deployment of atmospheric instrumentation. This has included development of the first airborne computerized data acquisition system, early development and deployment of cloud spectrometers, particle imaging probes and the development of airborne Cloud Condensation Nuclei Counters (CCNC). More recently, the department has led the development of remote sensing instruments including the Wyoming Cloud Radar (WCR) and Wyoming Cloud Lidar (WCL), both of which are now part of the Wyoming King Air aircraft NSF national facility and the newly-developed Multifunction Airborne Raman Lidar (MARLi). In several cases there has been demand from other research institutions to purchase versions of instruments developed in house.

Alpenglow Instruments LLC, founded by Professor Zhien Wang, Mr. Perry Wechsler and Mr. Nick Mahon in 2013, embodies the collaboration between science and engineering central to the success of the Atmospheric Science Department. Presently located in the Wyoming Technology Business Center (WTBC), Alpenglow Instruments has built, sold and installed two Airborne Elastic Cloud Lidars (AECL) and has just received an order for a third system. In addition, Alpenglow Instruments has received a SBIR Phase 1 grant from the Department of Energy to develop a Raman scattering based all-phase water probe, which leverages departmental expertise in both remote sensing (specifically the development of MARLi) and in the development of in situ probes for airborne atmospheric research. Alpenglow anticipates revenue approaching $500,000 for 2016 and is currently preparing a SBIR Phase 2 commercialization proposal, which could culminate in grant funding of up to $2 million.

High tech spin-off companies, such as Alpenglow Instruments, are an example of how University of Wyoming investments in research can be leveraged into potentially major benefits to the state economy. Alpenglow CEO Perry

Wechsler, a Senior Research Scientist in the UW Department of Atmospheric Science, expects the company to grow to 5-10 employees in the next two years. The close association and support from the University of Wyoming, the Department of Atmospheric Science and the WTBC has been critical to the success of this small, high tech business.

c. Program reputation

   i. If program is ranked, include rank and by what organization.

   University of Wyoming graduate programs were not included in the most recent (2010) National Research Council report (in which Atmospheric Science programs were reviewed).

   ii. Include a brief description of any other indicators of program reputation such as demand (e.g. waiting lists or over enrollment) for admission into program, employer data/feedback, etc.

   The Department of Atmospheric Science supports the University of Wyoming King Air research aircraft facility though a Cooperative Agreement with the National Science Foundation. The origin of this NSF agreement reaches back to the 1980s. We are now working on the Seventh Cooperative Agreement with NSF. As part of the Cooperative Agreement, the University of Wyoming King Air is an NSF National Facility that serves researchers in the U.S. and abroad with a platform capable of monitoring atmospheric conditions in the lower troposphere. Of all NSF Lower Atmosphere Observing Facilities (an array of ~20 aircraft, radars, sounding and surface systems across the nation), the UWKA has been requested and deployed the most, with a total of 50 deployments in the last two decades (1992-2015; Avallone and Baeuerle 2016). As such it has maintained a high visibility within the research community as demonstrated by its role in large field projects during the past three decades. Most recent deployment of note is in support of the Plains Elevated Convection Experiment, a large multi-agency effort during the summer of 2015 (e.g., http://www.pecan15.org/home/; http://www.nssl.noaa.gov/projects/pecan/; https://www.eol.ucar.edu/field_projects/pecan)

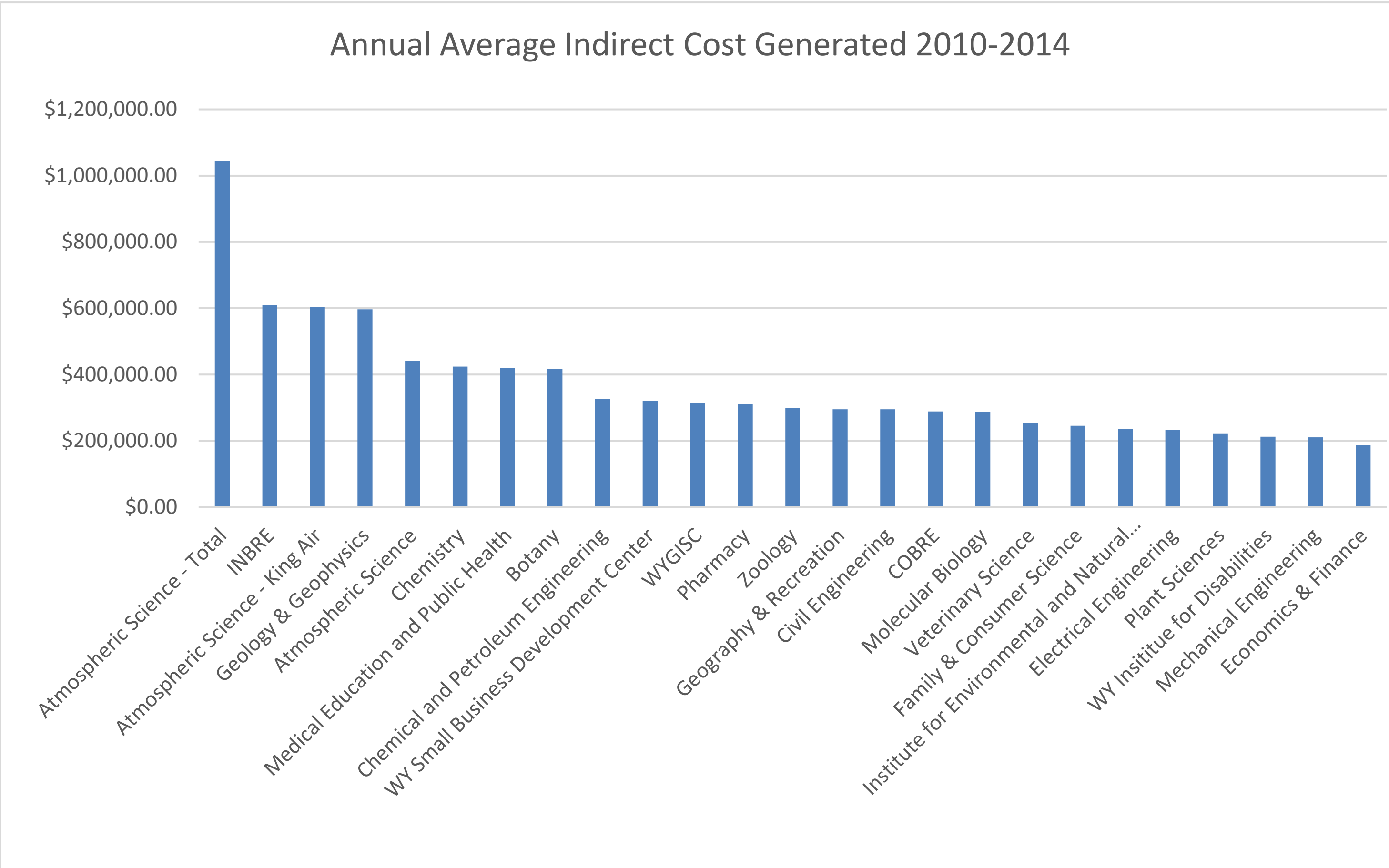
Avallone, L., and B. Baeuerle, 2016: A 20-year history of NSF-supported atmospheric science field campaigns: statistics and demographics. Bull. Amer. Meteor. Soc, in review.

(Note: Dr. Avallone is the NSF Program Manager in charge of the Lower Atmosphere Observing Facilities (LAOF) of which the University of Wyoming King Air is part.)

Aircraft measurement capabilities include in-situ sampling of precipitation physics, atmospheric dynamics, air chemistry and aerosols and extensive remote sensing capabilities. State-of-the-art instrumentation has been designed and developed within the Atmospheric Science group including the Wyoming Cloud Radar (WCR), the Wyoming Cloud Lidar (WCL) and the recent Multi-function Airborne Raman Lidar (MARLi). Both the WCR and the WCL are NSF National Facilities that have been routinely utilized by the Atmospheric Science community.

The Department of Atmospheric Science has consistently been one of the top users of the NCAR-Wyoming Supercomputing Center (NWSC), which is located in Cheyenne. As part of the Wyoming-NCAR Alliance, the university receives approximately 75 million core-hours per year. For the past June 2016 competition, a total of 42.6 million core hours were awarded to 9 projects led by the University of Wyoming faculty members. Professor Liu's group received 25.3 million core hours, or approximately 60% of the total university's allocation for that period. These resources are used to advance our understanding of climate and cloud systems using novel numerical modeling techniques and high-resolution simulations.

The Department of Atmospheric Science has routinely been one of the most productive research departments at the University of Wyoming with research expenditures around $4M per year. Indirect cost returns to the University of Wyoming from Atmospheric Science research activity are the largest on campus. For the years 2010-2014, the Department of Atmospheric Science was responsible for an average of $1.1M in indirect costs returned to the University of Wyoming. This compares to the total state support for the Department of Atmospheric Science of (as of 7/1/2016) $1.004M. A depiction of the yearly-average indirect cost returns by key department/units on campus for the five-year period 2010-2014 is shown below.



d. Curriculum of major or specialization
   i. Include a list of courses by prefix, number, title required in the major or specialization (do not include general education course unless required as part of the major requirements.)

The Department of Atmospheric Science curriculum has been reconfigured for the 2015-2016 academic year based in part on responses from former students as part of a recent Program Assessment. Required classroom and software skills after graduation were addressed as part of the survey. In addition, program outcomes included meeting requirements for M.S. graduates to attain proficiency required for General Schedule Qualification Standards Meteorology Series, 1340 (to be eligible for consideration for federal civil service meteorological positions - the National Weather Service).

Atmospheric Science Core Curriculum (incoming M.S.-level students)

Year 1 – Fall Semester
ATSC 5010 – Physical Meteorology I (4 credits)
ATSC 5014 – Dynamic Meteorology (4 credits)
ATSC 5018 – Ethics and Research Methods (1 credit)

Year 1 – Spring Semester
ATSC 5011 – Physical Meteorology II (4 credits)
ATSC 5014 – Synoptic and Mesoscale Meteorology (4 credits)

Year 2 – Fall Semester
ATSC 5040 – Climate Science and Climate Change (3 credits)
ATSC XXXX – Atmospheric Science elective class (3 credits)

Year 2 – Spring Semester
ATSC XXXX – Atmospheric Science or outside elective class (3 credits)

(Total 26 formal classroom credits)

e. Distance delivery of program/major *(N/A)*
   i. Note if the program is offered online and/or at one of the off-campus attendance centers (e.g., UW-Casper)

f. Quality of Assessment Plan/data
   i. Include a brief description of the program assessment plan and how the data are used to inform decisions related to program quality and student learning.

   We have taken a more aggressive approach to program assessment during the past two years. A survey was circulated to former students of the past 10 years to assess appropriate skill set and software to prepare for careers. This has prompted changes in the curriculum that were implemented in Fall Semester 2015. We have found as part of that assessment that nearly all former students are employed in a field that is directly tied to atmospheric science. Current assessment document for the M.S. program submitted on 15 July is attached as Appendix iii.

g. Strategic Plan
   i. Include a brief description of any plans for the program or specialization that appear in the college/department strategic plan (i.e., facilities upgrades, curriculum changes, on-line or off-campus delivery, enrichment learning opportunities, etc.)

   Atmospheric Science has identified three areas for program development:
   1. ***increase research aircraft lifespan***
   2. ***increase graduate degrees granted***

3. ***increase student credit hours taught by department faculty***

Research Aircraft: *Our central focus from the previous year is to replace our current aircraft. Extensive research and planning was conducted to identify the next aircraft and a plan of funding was put in place. The state legislature agreed to a loan for the purchase, with payments to be from departmental income. An aircraft purchase agreement was signed and delivery was expected in June 2016. The agreement was cancelled by UW due to budget factors in April. To continue work with our current N2UW aircraft we have hired a consultant to reassess the lifetime of the airframe therefore allowing us move forward with our research.*

Degrees Granted: *A second major focus is to increase the number of graduate students in our program and to increase the M.S. and Ph.D. production rates. The department is taking steps to increase the number of degrees granted to be proportional to the research dollars brought into UW. This effort was initiated two years ago and the number of enrolled graduate students has increased from 19 in 2012 to an expected 32 in the Fall Semester 2016, all of them with graduate assistantships, but only one with a state GA. This increase in the number of graduate students results from concerted efforts to increase number of admitted students into our program through improved recruitment efforts and to recruit higher caliber graduate students leading to higher retention rates. The recent increase in the number of students recruited and retained has occurred during a time when the number of state-funded GA's within the department has decreased from 3 to 1.*

The Department of Atmospheric Science has had a solid record in terms of acquiring research funds. As part of meetings between faculty members and the Department Head and as part of the College of Engineering and Applied Science's annual review process, goals are established in terms of teaching expectations and research productivity. A goal for graduate student enrollment has been established to increase the number to approximately 40 in the next two years. A further goal is to reduce the effective time-to-degree for M.S. students to four semesters. This is accomplished by changes in the course curriculum and changes in the transition from M.S. to Ph.D. status. The net result of the increased enrollment and decreased time-to-degree is a significant increase in number of degrees offered: we expect a doubling of graduate degrees in the next five years, compared to the last five years. Finally, we plan to continue to increase the Ph.D.:M.S. ratio, consistent with UW's aspiration to maintain its Carnegie Foundation Research Universities — High Research Activity (RU/H) status.

Student Credit Hours Generated by Teaching: *A third area of focus is on education. Metrics compiled by Associate Dean Paul Dellenback showed low student credit hours taught by the Atmospheric Science faculty. This deficiency was immediately addressed in the Spring Semester 2016 faculty* *meeting. In academic year 2015-2016, the Department of Atmospheric Science taught a total of 940 student credit hours. A two-year goal is to double that number. This effort is also in line with President Nichol's vision of enhancing faculty teaching loads.*

To meet this goal, three strategies have been put in place commencing in academic year 2016-2017. First, a series of undergraduate courses is being developed to serve the university community. Those courses include First Year Seminar course ATSC1101 (Weather, Climate and Global Change) and ATSC 2100 – Global Warming. Both will be taught during the Fall Semester 2016. Currently under development are courses in Atmospheric Chemistry (primarily for Atmospheric Science graduate students although thought to be of use for students in Chemical Engineering) and an undergraduate survey course in Severe Weather. Assistant Professor Zach Lebo is spearheading the latter effort based on a similar course at Penn State University where he did his B.S. and M.S. work. All such courses will be approved PN courses under the new USP 2015. Given changes in the USP 2015 curriculum (i.e., no required laboratory sections), it will be possible to service large sections of these courses. The ATSC 2100 (Global Warming) course, in particular, has been targeted for growth given the compelling and controversial issues surrounding the science of global change.

A second strategy is to double our service to the Engineering Science program. We have taught Engineering Science courses for the past 35 years. Recently one large section has been serviced by Atmospheric Science faculty each semester in either ES 2110 (Statics), ES 2120 (Dynamics) or ES 2310 (Thermodynamics). We will double that effort in Academic Year 2016/17. Dr. Robert Kelly will teach a large section (~80 students) of ES 2110 and Dr. Jefferson Snider will teach a large section of ES 2310. In the spring, Drs. Kelly, Parish and Snider will teach separate sections of ES.

A third strategy will be to increase the teaching of elective courses in Atmospheric Science to our growing M.S. and Ph.D. crop of students. Our goal is to increase student credit hours taught per faculty member to be comparable to other units within the College of Engineering and Applied Science.

h. Other:

3. **Mission Centrality: Does the program advance the mission of UW including institutional strategy?**
   a. Describe how the program supports the mission, vision and strategic goals of UW.

   University Plan 4 remains in draft phase so reference is made to University Plan 3. Critical areas of science and technology are listed on page 1, including "earth and *energy sciences and technology" and "water resources." Research in the Department of Atmospheric Science encompasses those areas. Recent NSF research grants include assessment of enhancement of increasing mountain snowpack by cloud seeding, the first such funded NSF research on weather modification in nearly 30 years. The Department of Atmospheric Science has a long history in studies of the precipitation process of the high western landscape.*

As part of the Tier 1 Engineering Initiative, Atmospheric Science was highlighted as a "niche area of excellence at UW". The "Atmospheric Science program is viewed as a model for developing sustained niches of excellence in graduate education." In reference to the Department of Atmospheric Science, the Tier 1 reports concludes, "the depth of faculty resources, coupled with valuable assets unique to UW and the state, provide a formula for lasting excellence that we intend to emulate in other niche areas" (see the University of Wyoming Engineering Initiative: Toward Tier 1 for Wyoming report http://www.uwyo.edu/acadaffairs/plans/uw_engineering_initiative_may_13.pdf).

b. Describe how the program contributes to other programs across campus (i.e., general education courses, minor or support courses, interdisciplinary program, etc.)

The Department of Atmospheric Science offers undergraduate courses to the university community in general meteorology (ATSC 2000) and issues and the science associated with global warming (ATSC 2100).

During the past decade an attempt was made to provide an interdisciplinary undergraduate degree in Earth System Science, in collaboration with several departments from two other colleges. The atmospheric science concentration for the program did not attract sufficient student numbers, however, and was discontinued in 2014.

c. Include placement data for graduates and indicate if graduates are working in the field or not.

A recent survey was sent to former graduates as part of the assessment process. Data collected indicated that all our graduates were working in the atmospheric science area. As part of our assessment process, we are working to update our contact information to enable a more complete and statistically-significant analysis.

d. Describe the uniqueness or duplication of this program across the UW.

The Department of Atmospheric Science holds a unique niche at the University of Wyoming. It houses research as well as transportation flying for the University of Wyoming. Research activities conducted by faculty and staff within Atmospheric Science focus on aspects of the precipitation process and other related issues have been the hallmark of this group for five decades. This allows students to acquire first-hand experience in collecting data that is used in their research. Given the strong *observational nature of our program, students acquire unique experience in instrumentation development/testing, statistical methods, and critical analysis. Our graduate program is rather unique nationwide.*

During the past two years, we have expanded our research/teaching activities to the modeling of climate, clouds and precipitation, a critical component of atmospheric sciences for predicting future climate changes.

There is a clear need for such programs (Serafin et al. 1991; Takle 2000), and in fact a continued concern that graduates in atmospheric sciences lack training in hands-on atmospheric technology (Horel et al. 2013).

Horel, J. D., D. Ziegenfuss, and K. D. Perry, 2013: Transforming an atmospheric science curriculum to meet students' needs. Bull. Amer. Meteor. Soc., ***94****, 475–484.*

Serafin, R., B. Heikes, D. Sargeant, W. Smith, E. Takle, D. Thomson, and R. Wakimoto, 1991: Study on observational systems: A review of meteorological and oceanographic education in observational techniques and the relationship to national facilities and needs. Bull. Amer. Meteor. Soc., ***72****, 815–826.*

Takle, E., 2000: University instruction in observational techniques: Survey responses. Bull. Amer. Meteor. Soc., ***81****, 1319–1325*

e. Other:

4. **Cost: Is the program financially viable?**

a. Ratio of student credit hours per FTE

During FY 2015, Atmospheric Science faculty taught 938 student credit hours. From the 2016 Budget Index, Atmospheric Science has 8.674 FTE faculty lines.

Our ratio of student credit hours per FTE of 108.1 student credit hours in FY 2015 has been targeted for improvement. As discussed earlier, we will introduce three new undergraduate courses including a First Year Seminar class during the next academic year and double our Engineering Science participation.

b. Direct instructional expenditures:

Current State of Wyoming support for faculty in the Department of Atmospheric Science is $969,779. Using a five-year average as discussed above, 4.8 M.S degrees and 1.6 Ph.D. degrees were granted per year.

i. Per student credit hour
$1034/student credit hour

ii. Per total degrees awarded
$151,528/graduate degree granted

iii. Non-personnel expenditures per total academic FTE

c. Course enrollment
    i. Number of classes falling under University minimums

    During the past academic year we had three classes taught at the undergraduate level that did not meet minimums. These classes were offered to allow the final Earth System Science students to graduate.

    ii. Lower-division courses falling under University minimums
    See above

d. Other instructional cost drivers, such as:
    i. Section fill rates
    Given the graduate nature of our department, fill rates are zero.
    ii. Course completion rates
    We have routinely 100% course completion rates, again not significant given our graduate status.
    iii. Curricular complexity
    Mostly standard classroom situations. Lab components as part of our revised curriculum are more demanding with computer-related exercises and numerical modeling requirements.
    iv. Faculty course load
    Prior to recent changes in course loads, our typical teaching loads were 2/1 for nearly all faculty.

e. Research expenditures per tenured/tenure-track FTE (and other academic personnel, where appropriate)

    During FY 2016, our research expenditures amounted to $3.72 M. We have 8.674 FTE faculty corresponding to $429,000 per tenured/tenure-track FTE. This is comparable to the National Research Council top-ranked Atmospheric Science departments in the U.S.

f. Compare your data to national benchmarks (Delaware data)

    Our ratio of student credit hours per FTE is a weakness but our research productivity compares with highly productive departments at major research institutions as noted in the above Engineering Tier I report.

g. Other

Appendix i: List of M.S. Graduates (Fall 2011-Summer 2016)

H. George Randolph, M.S. Spring 2012 (Parish)

Jayson Stemmler, M.S. Fall 2012 (Snider)

Xin Zhou, M.S. Spring 2013 (Geerts)

Emery, Brittni, M.S. Spring 2013 (Montague)

Christopher Kruse, M.S. Spring 2013 (Parish)

David Siuta, M.S. Spring 2013 (Parish)

Liran Peng, M.S. Summer 2013 (Wang)

Shauna Ward, M.S. Summer 2013 (Deshler)

Sujan Khanal, M.S. Summer 2013 (Wang)

Xia Chu, M.S. Summer 2013 (Geerts)

Yang Yang, M.S. Fall 2013 (Geerts)

Adam Wettlaufer, M.S. Fall 2013 (Snider)

Jaclyn Ritzman, M.S. Fall 2013 (Deshler)

Philip Bergmaier, M.S. Summer 2014 (Geerts)

Xiaoqin Jing, M.S. Summer 2014 (Geerts)

Dustin Snare, M.S. Spring 2015 (Murphy)

Rudra Pokhrel, M.S. Spring 2015 (Murphy)

Eric Beamesderfer, M.S. Spring 2015 (Murphy)

Rebecca Pauly, M.S. Fall 2015 (Wang)

Daniel Welsh, M.S. Fall 2015 (Geerts)

Timothy Juliano, M.S. Fall 2015 (Kelly)

Jason Sulskis, M.S. Spring 2016 (French)

Adam Tripp, M.S. Summer 2016 (Kelly)

Dana Mueller, M.S. Summer 2016 (Geerts)

Appendix ii: List of faculty peer-reviewed publications (2012-2016)

Deshler:

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Kremser, S., L.W. Thomason, M. von Hobe, M. Hermann, T. Deshler, C. Timmreck, M. Toohey, A. Stenke, J. P. Schwarz, R.Weigel, S. Fueglistaler, F. Prata, J-P. Vernier, H. Schlager, J. Barnes, J-C. Antuña-Marrero, D. Fairlie, M. Palm, E. Mahieu, J. Notholt, M. Rex, C. Bingen, F. Vanhellemont, A. Bourassa, J. M. C. Plane, D. Klocke, S. A. Carn, L. Clarisse, T. Trickl, R. Neely, A. D. James, L. Rieger, J. C. Wilson, and B. Meland, (2016), Stratospheric aerosol - Observations, processes, and impact on climate, Rev. Geophys., in press

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Campbell, P., M. Mills, *and* T. Deshler *(*2014*)*, The global extent of the mid stratospheric CN layer: A three-dimensional modeling study, *J. Geophys. Res. Atmos.*, *119*, doi:*10.1002/2013JD020503*.

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Appendix iii – Draft of M.S. Assessment Plan Summer 2016

Tier 3–Assessment of Student Learning Outcomes Report

Department or program name: Atmospheric Science

Name of degree/program assessed:

Program Level (check one):

________ Undergraduate

____X__ Masters

________ Doctorate

Submitted by: Assessment Committee, Department of Atmospheric Science (Thomas Parish, Charlotte While, Jefferson Snider, Zachary Lebo)

Date submitted: July 5, 2016

1. **Please reflect on your program's assessment process and feedback provided by the University Assessment Coordinators Committee last year. What did you change or do differently with regards to your assessment processes? Provide at least two concrete examples. (<u>If you did not submit a report last year, please indicate this.</u>)**

Feedback from last year indicated a lack of specific student learning objectives and a process by which those objectives were evaluated. In response to this, a committee was formed to focus on assessment of learning objectives. The committee consists of Department Head Thomas Parish, Charlotte While, Jefferson Snider and Zachary Lebo. A list of student learning objectives was developed and circulated. Although not formally submitted as part of last year's report, extensive discussion had taken place the previous year as part of a curriculum revision. Findings from that review were incorporated in the list of learning objectives.

Curriculum revisions (see attached) were made based on new learning objectives. In particular, Climate Science (ATSC 5040) is now a required course in our curriculum. We established as a key leaning objective for all students is familiarity with the science of global change. Other courses have incorporated other aspects of student learning such as papers written in the format for refereed journals and student presentations of research topics in particular courses.

2. Do you have student learning outcomes for your degree/program? If yes, please list them here. (Please note that student learning outcomes for your graduate program should be different from those you may have for your undergraduate program since a higher level of learning would be expected.)

Here we are specific to the M.S degree program. At present we only offer a Plan A thesis option for our students. We have starting dialogue regarding a Plan B or other option for the M.S. degree. That will be a topic of discussion for next year. Such a discussion is, in part, due to a recognition that most of our M.S. graduates are now employed in non-research positions.

A summary and list of student learning objectives for the M.S. program:

MS Degree:

The M.S. degree is intended to develop scientific capabilities through graduate courses and research. The research is to be demonstrated through completing a research thesis that is expected to be accomplished in two years. The results of such research should be sufficient for a peer-reviewed publication in a journal of the American Meteorological Society (AMS) or American Geophysical Union. The M.S. program prepares students for supporting scientific research in governmental, academic, or private laboratories, teaching at the secondary or community college level, private consulting or position at the National Weather Service or World Meteorological Organization. The degree may lead directly to employment or may be a step toward a Ph.D.

M.S. students in the Department of Atmospheric Science will be required to:

1) Demonstrate a working knowledge of the physics and dynamics of the atmosphere as measured by means of successful completion of all core courses (Need to complete all core courses with a grade of B or better).
2) Demonstrate an understanding of the scientific principles and modeling techniques used in studies of climate change and its influence on broader change within the earth system.
3) Possess analytical and mathematical skills necessary to develop insight into physical processes in the atmosphere.
4) Show broad familiarity with the literature in the area of the research thesis, sufficient to prepare publication in the refereed literature.
5) Demonstrate an ability to analyze and synthesize data (observations and/or modeling) necessary in the thesis research and present such analyses in a public seminar.
6) Demonstrate an ability to communicate research results in the form of written reports, visual displays, and scientific presentations.
7) Meet the skill level required for General Schedule Qualification Standards Meteorology Series, 1340 (to be eligible for consideration for federal civil service meteorological positions - the National Weather Service).

3. **What discussions have taken place with the faculty regarding assessment of student learning outcomes? Please provide details of the meeting(s) and who was involved.**

The curriculum has been totally revamped (see Appendix 1) to include Climate Science as a required core course. It was concluded based on results of a survey of previous students, discussions at professional meetings and faculty discussion that basic principles of climate science should be a component of the core curriculum for all students. Discussion also has taken place in faculty meetings (all faculty participated) regarding assessment of students who will terminate with an M.S. degree and those who should be encouraged to continue for the Ph.D. In particular, it was decided that a Qualifying Assessment should be given after the first year for incoming students. What material should comprise the first year of studies? What learning objectives should be completed? This has shaped what material and what learning objectives should be incorporated within the first year of our program.

This is not to say we have total agreement with what goals should be set for student learning. During this coming year, we will again address the issue of Atmospheric Chemistry and whether some basic knowledge and assessment be required beyond the usual topic covered in our core courses of Physical Meteorology I and Physical Meteorology II. Our learning objectives can best be described as a living document.

4. **What steps have your department/program taken over <u>the last year</u> to implement your assessment plans (if plans were in place)? Include specific examples such as curriculum mapping or developing tools such as rubrics, development of test questions, surveys, etc. and indicate which student learning outcomes were assessed.**

As part of the previous year, a survey was developed that was emailed to all former graduates of our program. Responses from that survey were used to refine the new curriculum. For example, results clearly showed that former students thought climate science should be a required part of the new curriculum. Other questions asked former students what software skills were most applicable beyond the classroom. This has prompted a dialogue regarding what software skills are best applicable to ensure student success within the classroom as well as in the real world. Some have advocated away from proprietary software such as IDL and MATLAB to open source Python.

As a means for measuring outcomes, individual classes within the new curriculum have requirements that now evaluate student performance based on the specified objectives shown above. For example, new ATSC 5014 (Dynamic Meteorology) now requires students to become proficient in using the Weather Research and Forecasting Model (WRF) matching learning objectives 3 and 5 above. They learn to download and assemble all parts of the code, run the model for a real-world case and conduct a short research project based on their WRF simulation. Students then write a scientific paper in a format identical to that required for submission to an AMS journal and give an open oral presentation following usual AMS conference format (objective 6). This is conducted in the first semester. A similar requirement follows during the second semester in ATSC 5016 (Synoptic and Mesoscale Meteorology). Another course in the new curriculum is ATSC 5018 (Ethics and Research Methods) that is focused on addressing requirements from the National Science Foundation as well as to provide a first look at how to conduct research and how to present results (objectives 4, 5 and 6).

Another example is the courses sequence in physical meteorology. Here the new courses - ATSC5010 (Physical Meteorology – I) and ATSC5011 (Physical Meteorology – II) - have updated computer laboratory modules (updated in the past 12 months) that focused on graphical display of data, solving transcendental equations, and numerical integration of a system of ordinary differential equations (objectives 2, 5 and 6).

5. Do you have any assessment of student learning results to share? If so, please include.

What are the plans for your program to improve from Tier 3 to Tier 2 status? What concrete steps will you take next year to improve? Provide timeline and who will be involved. (Go to http://www.uwyo.edu/assessment/annual-reports/ for definitions of each assessment tier).

Student performance in the papers and presentations was promising, although foreign students struggle with the language in terms of written papers and oral presentation. As a result of the assessment process, we have discussed requiring all our non-native students to achieve at least a grade of Advanced Mid of English proficiency as determined by ESL Coordinators. As is, we will require all our non-native students to at least enroll in ESL courses, despite the fact that few will ever teach.

Other steps will include exit interviews with all M.S. students who have successfully defended their theses. The interview structure will follow questions that were administered as part of the survey to former graduate students (see attached) that pertain to the curriculum and success at conducting research.

Appendix 1

Department of Atmospheric Science

Graduate Core Curriculum Revision

Summary Statement

This proposed curriculum change for the Department of Atmospheric Science is a minor update to the extensive modifications to the program back in 2006. At that time innovative courses addressing both theoretical concepts in atmospheric science and hands-on skills incorporating computer programming languages, data visualization interfaces, statistical data analysis techniques and atmospheric measurement systems were introduced. During the past decade, this core program has worked out quite well as evidenced by comments from former students obtained as part of an ongoing program assessment.

During the past decade, climate science has become an increasingly important discipline in atmospheric science. As a department, we have concluded that we need to prepare our students to take part in this climate change dialogue. Issues of global change have become compelling issues in contemporary society. The need to formally integrate climate science within our core curriculum is the key driver of changes proposed here. In addition, new hires have enabled us to develop research proficiency in climate science. Two years ago we hired Dr. Xiaohong Liu, an internationally-known expert in climate modeling, into the position of Wyoming Excellence Chair in Climate Science. We have recently hired Dr. Zachary Lebo to complement our climate modeling and climate expertise. Given the changes in our research direction and in general trends within the atmospheric science community, we deemed it prudent to ensure our students are presented with climate science as a core-course within our curriculum.

Adding another three-credit course has forced us to make some changes. We have combined the first semester sequence of courses ATSC 5001 (Atmospheric Energetics – 2 credits), ATSC 5002 (Atmospheric Radiation I – 3 credits) and ATSC 5003 (Problems in Energetics and Radiation – 1 credit) into one four-credit course ATSC 5010 (Physical Meteorology I). The reduction in total credit hours from five to four hours will imply that some course material from the old curriculum will be moved into the second semester sequence. Also during the first semester, the ATSC 5004 (Problems in Dynamic Meteorology – 1 credit) and ATSC 5100 (Atmospheric Dynamics I – 3 credits) will be replaced by a single 4-credit hour course ATSC 5014 (Dynamic Meteorology).

During the spring semester of the first year, we have replaced the sequence of ATSC 5005 (Microphysics – 2 credits) and ATSC 5006 (Problems in Microphysics – 1 credit) with a four credit course ATSC 5011 (Physical Meteorology II). The increase in total credit hours includes course topics previously covered in the first semester sequence of courses. A second set of courses being replaced is ATSC 5007 (Problems in Synoptic Meteorology – 1 credit) and ATSC 5160 (Synoptic Meteorology – 2 credits) with a 4-credit hour course ATSC 5016 (Synoptic and Mesoscale Meteorology). The increase in one credit is due to the inclusion of course material from the old curriculum course Mesoscale Meteorology that is no longer included in the core.

ATSC 5040 (Climate Science and Climate Change – 3 credits) is the new core course and is to be taken during the fall semester of year 2. As noted above, we have moved content from former core course ATSC 5008 (Mesoscale Meteorology – 2 credits) into ATSC 5016 and have made ATSC 5210 (Cloud and Precipitation Systems – 3 credits) into an elective course.

In response to the diversification of research conducted by faculty, we have added an additional "elective course" option for our graduate students. Hours of formal coursework under this new curriculum have decreased by one credit, from 27 to 26 hours. We have attempted to maintain a balance between the requirements of offering core material and "real-life" problem solving skills of the previous curriculum with the need to introduce climate science. All changes are also summarized in Table 1 below.

We also are committed to ensure that our program will enable M.S.-level graduates to qualify for traditional forecast positions within the National Weather Service or World Meteorological Organization. Curriculum revisions are somewhat constrained by requirements for entry into the federal civil service meteorological positions (see attached GS-1340 requirements).

Course Request Forms have been completed to delete courses as part of the "old" curriculum as well as to update prerequisites to existing elective courses.

Table 1 – Summary of Department of Atmospheric Science revised M.S.-level graduate curriculum.

YEAR 1 – Fall Semester					
New Curriculum			Old Curriculum		
Course No.	Title	Cr.	Course No.	Title	Cr.
ATSC 5010	Physical Meteorology I	4	ATSC 5001	Atmospheric Energetics	2
			ATSC 5002	Atmospheric Radiation I	3
			ATSC 5001	Problems in Energetics and Radiation	1
ATSC 5014	Dynamic Meteorology	4	ATSC 5003	Problems in Dynamic Meteorology	1
			ATSC 5100	Atmospheric Dynamics	3
ATSC 5018	Ethics and Research Methods	1			

YEAR 1 – Spring Semester					
New Curriculum			Old Curriculum		
Course No.	Title	Cr.	Course No.	Title	Cr.
ATSC 5012	Physical Meteorology II	4	ATSC 5005	Microphysics	2
			ATSC 5006	Problems in Microphysics	1
ATSC 5016	Synoptic and Mesoscale Meteorology	4	ATSC 5007	Problems in Synoptic Meteorology	1
			ATSC 5160	Synoptic Meteorology	2

YEAR 2 – Fall Semester					
New Curriculum			Old Curriculum		
Course No.	Title	Cr.	Course No.	Title	Cr.
ATSC 5040	Climate Science and Climate Change	3			
ATSC XXX	Atmospheric Science elective course	3			
			ATSC 5008	Mesoscale Meteorology	2
			ATSC 5120	Cloud and Precipitation Systems	2

YEAR 2 – Spring Semester					
New Curriculum			Old Curriculum		
Course No.	Title	Cr.	Course No.	Title	Cr.
XXXXX	ATSC or outside elective course	3	XXXXX	ATSC or outside elective course	3

Assessment of ATSC Curriculum and US Government Requirements for GS-1340

Requirements for GS-1340 (Meteorology Series) based on the following website:

http://www.opm.gov/qualifications/SEC-IV/B/GS1300/1340.HTM

A degree in meteorology, atmospheric science, or other natural science major that included at least 24 semester hours of credit in meteorology/atmospheric science including a minimum of:

Category	*Description of Category*
A	6 semester hours (SH) of atmospheric dynamics and thermodynamics*
B	6 SH analysis and prediction of weather systems (synoptic/mesoscale)
C	3 SH physical meteorology
D	2 SH remote sensing of the atmosphere and/or instrumentation.
E	6 SH physics, with at least one course that includes laboratory sessions*
F	3 SH ordinary differential equations*

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

*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.

…………………………………………………………………………………………..

Assumed starting point for entry into the ATSC Graduate Program:

3 semester hours of differential equations

One-year sequence in physics lecture and laboratory courses, with calculus as a prerequisite or corequisite

6 semester hours of physics lecture

1 semester hour of physics laboratory

ATSC Graduate Curriculum and US Government Requirements for GS-1340

Course No.	Title	SH	Category	Total SH
ATSC 5010	Physical Meteorology I	4	A/B/C	2/1/1
ATSC 5015	Dynamic Meteorology	4	A/B	3/1
ATSC 5016	Synoptic and Mesoscale Meteorology	4	B	4
ATSC 5011	Physical Meteorology II	4	C/D	3/1
ATSC 5040	Climate Science and Climate Change	3	C/D	2/1
Prerequisite	College Physics	6	E	
Prerequisite	College Physics Laboratory	1	E	
Prerequisite	Differential Equations	3	F	
ATSC Elective		3	varies	
ATSC Elective		3	varies	

Appendix 2

Survey to former students:

Dear Atmospheric Science Graduate:

Greetings! We have been undergoing some rather significant changes during the past few months here at the University of Wyoming. As you may know, Dr. Al Rodi has taken over as Dean of the College of Engineering and Applied Science and I am now the Department Head. Both Dr. Rodi and I have made a pledge to reach out to our former students. We feel you are the best source of information regarding our graduate program!

On my agenda is the core curriculum. I am asking for help in assessment of how we have done and what changes would be appropriate. We last revised our curriculum in 2006 and introduced a series of one-credit "Problems" courses to supplement lecture material. After eight years, we are now considering revising the curriculum. We have recently hired a new faculty member in the area of climate science and are considering including climate as part of our core curriculum. I am asking for a few moments of your time in completing a questionnaire. Your honesty and frankness will be appreciated as we move forward with the curriculum planning process. All responses to your questions will be kept confidential. Thanks in advance for your help!

1. What has proved to be the most helpful things you learned in your graduate program?

2. What courses were the most applicable/useful to your graduate program?

3. What courses were the least applicable/useful to your graduate program?

4. What course or courses do you wish you would have taken or had been offered?

5. What software skills (developed in the Problems courses) were the most applicable/useful to your graduate program?

6. What software skills (developed in the Problems courses) were the least applicable/useful to your graduate program?

7. Climate has become a huge societal issue. How do you feel about integrating climate into the core curriculum? If you feel this is useful, what topic areas can we reduce or eliminate?

8. We are planning to revise ATSC5001 (Atmospheric Energetics), ATSC5002 (Atmospheric Radiation) and ATSC5005 (Microphysics). In particular, we plan to focus on the interplay among these topics and how they integrate into the more advanced courses, especially ATSC5040 (Climate Science and Climate Change) and ATSC5210 (Cloud and Precipitation Systems). Please reflect on your experience in ATSC5001, ATSC5002 and ATSC5005, and how you think we can improve the delivery of these topics.

General Questions:

Where are you now living?

What are you/have you been doing?

Are you employed in a position that requires skills learned as part of your graduate training?

Part II - Recommendations

Instructions: *After the review is completed, the Dean in consultation with the Department Head will select one of the following recommendations. In the justification, address each of the items associated with the recommendation.*

1) **Retain Due to Critical Need**
   a) A college may recommend that a degree program be retained due to its ability to fulfill a critical workforce need or shortage area for the state.

   b) Justification for retaining due to critical need must include:
      i) Explanation of why the program is important to the University/State/region
      ii) Description of specific steps (already taken and/or planned) to increase enrollment and graduate production;
      iii) Preliminary outcomes of steps taken.

2) **Retain with Further Review Required**
   a) A college may request that a program be retained for further review for those degree programs that serve a specific function central to the mission of the college or university.

   b) Justification for retain due to further review must include:
      i) Explanation for how the program is central to the university's mission and the benefit to the system;
      ii) Description of specific steps (already taken and/or planned) to increase enrollment and graduate production;
      iii) Preliminary outcomes of steps taken.

3) **Consolidate with Another Program within College**
   a) A college may request that a program be consolidated with a similar program on campus that achieves similar degree requirements.

   b) Justification to consolidate with another program on campus must include:
      i) Explanation for how the degree requirements for the two programs warrant consolidation;
      ii) Evidence that the consolidation will meet graduate production thresholds, or specific steps to increase enrollment to meet production thresholds;
      iii) Preliminary outcomes of steps taken.

4) **Consolidate with Program(s) between Colleges/campuses (e.g., UW/C)**
   a) Two or more colleges may request that similar degree programs be consolidated to maintain equivalent degree programs.

   b) Justification for retaining due to cross-college consolidation must include:
      i) Explanation for how the consolidated programs will collaborate (e.g., sharing of required courses, shared faculty, etc.) to maintain graduate production thresholds;

ii) Evidence that multi-college collaboration will meet graduate production thresholds, or specific steps to increase enrollment if merging programs fails to meet production thresholds;
iii) Preliminary outcomes of collaboration between colleges.

5) **Terminate**
   a) A college may request that a program be terminated due to limited graduate production, lack of student interest, shifts in a given field of study, or continued declines in major enrollments.
   b) If the exigency for termination results from the program productivity review process then a brief justification to terminate a program should be included. Such a justification must include:
      i) Explanation for the decline in graduate production in the degree program;
      ii) Intended timeframe for submitting a program termination request to the Board of Trustees for their consideration;
      iii) Expected timeline to meet teach-out requirements established through the regional accrediting body.

APPENDIX A

"Low Productivity" Programs Excluded from Review Process

1) **Major Program Modifications**
   a) Degree programs that have undergone recent program modifications that adversely impact graduate production for a college.
   b) Modifications traditionally include programs that have undergone recent name changes during the reporting window that result in two equivalent degree programs.

2) **Program/Major Specializations**
   a) Degree programs that have one or more specializations which reduce the total number of graduates.
   b) The exclusion may apply only for those specializations where the combination results in graduate production that meets the establish threshold for the degree.

3) **Terminated Programs**
   a) Degree programs that have been inactivated during the reporting period, but still depict graduates that fall below the established thresholds.
   b) Terminated programs will remain on the Program Productivity Report until inactive programs have completely cycled through the established reporting period.

4) **New Programs**
   a) Degree programs that have been activated within the past 7 years resulting in limited graduate production due to program implementation.
   b) Institutional review may be requested prior to the 7th year if graduate production is not scaling to the required thresholds for the degree level.

Academic Program Review
Report Template
University of Wyoming
Office of Academic Affairs
March 2016

(adapted from SDSU)

Deans and Directors who administer an authorized major or course of study approved by action of the Board of Trustees will be responsible for conducting program reviews. Four key elements should be addressed in each academic program review: (1) Program Demand, (2) Program Quality, (3) Mission Centrality, and (4) Cost.

For each program that is reviewed, a recommendation will be made by the Academic Dean to the Vice President of Academic Affairs.

Instructions: *Please provide the following information:*

Title of Program/Specialization: **Atmospheric Science**
Indicate whether undergraduate or graduate program/specialization: **Ph.D. Program**
Department and College: **College of Engineering and Applied Science**
Department Head Name and contact information (phone, email): Thomas R. Parish (parish@uwyo.edu, 766-5153)

Part 1 – Program Review

Instructions: *Please answer each of the following questions. Items listed under each question have been provided to help guide your response. If an item is not applicable, simply indicate "N/A".*

1. **Program Demand*:**
   (*Note: If degrees granted exceeds cutoff, delay review until next round*.)
   a. Number of graduates over 5-year period:

   Five Year Period: Fall 2011 – Summer 2016
   8 Ph.D. degrees granted – (List of graduating students and current students with estimated Ph.D. completions dates is attached as Appendix i)

   b. Enrollment in major/specialization over 5-year period: *(Fall 2011 – Summer 2016) incoming graduate students - 36*

* Cutoffs for "Low Demand" Designation -- *Degrees Granted*

- Bachelor's Programs: Average – 5 per year; 5-year total: 25
- Master's Programs: Average – 3 per year; 5-year total: 15
- Ph.D. Programs: Average – 1 per year; 5-year total: 5

(See APPENDIX A for the types of programs that will be excluded from review.)

2. **Program Quality: Is the program of high quality?**
   a. Program accreditation – *N/A*
      i. For programs currently accredited include:
         1. Name of accrediting body/organization
         2. Date most recently accredited
         3. Next reaccreditation date
         4. List recommendations from most recent visit and progress to date.
      ii. For programs seeking accreditation include:
         1. Name of accrediting body/organization
         2. Timeline for seeking accreditation
      iii. For all other programs include:
         1. Date of most recent Academic Program Review (APR)
            None in the past 10 years
         2. List of recommendations from the most recent APR and progress to date.
            N/A

      (Note: For first-time reviews, include N/A in response.)

   b. Credentials of faculty
      i. Include a list of all faculty by name, highest degree and discipline of highest degree.

      Jeffrey R. French, Ph.D., Atmospheric Science, University of Wyoming, 1998 (Assistant Professor).
      Bart Geerts, Ph.D., Atmospheric Science, University of Washington, 1990 (Professor).
      Robert D. Kelly, Ph. D., Atmospheric Science, University of Chicago, 1982 (Professor).
      Zachary J. Lebo, Ph.D., Environmental Science and Engineering, California Institute of Technology, 2012 (Assistant Professor).
      Xiaohong Liu, Ph.D., Atmospheric Science, Nanjing University, P.R. China, 1992 (Professor, Wyoming Excellence Chair in Climate Science).
      Shane M. Murphy, Ph.D., Chemical Engineering, California Institute of Technology, 2009 (Assistant Professor).
      Thomas R. Parish, Ph.D., Meteorology, University of Wisconsin-Madison, 1980 (Professor).
      Jefferson R. Snider, Ph.D., Atmospheric Science, University of Wyoming, 1988 (Professor).
      Zhien Wang, Ph.D., Atmospheric Science, University of Utah, 2000 (Professor).

      Recent retirees:

      Terry Deshler, Ph.D., Physics, University of Wyoming, 1982 (retired May 2014).
      Derek C. Montague, Ph.D., University of Southampton, UK, 1967 (retired May 2015).

Alfred R. Rodi, Ph.D., Atmospheric Science, University of Wyoming, 1981 (retired June 2016).

ii. Also, include a breakdown by gender and ethnicity.

9 males; 2 Asian, 7 Not Hispanic or Latino

iii. Grants awarded to academic personnel: Previous 5 years

Note: Only funded proposals obtained through peer-review process from external agencies listed:

Five Year (2011-2016) Summary: ~59 grants acquired, ~$23M in external funding

Deshler:

Balloon measurements of the Asian tropopause Aerosol Layer (BATAL) 2015, NASA, 6/15-12/15, $99K, PI

The KlAsh campaign - A Rapid Response for Balloon Measurements of the Mt. Kelud Volcanic Plume, NASA, 5/14-6/14, $104K, co-PI

In situ measurements of stratospheric aerosol size distributions and their use in a new aerosol surface area climatology, NSF, 9/10-9/16, $1.053M, PI

French:

SNOWIE: Seeded and Natural Orographic Wintertime clouds – the Idaho Experiment, NSF-AGS, 9/16-9/18, $797K, PI

Wyoming King Air as a National Facility, NSF-AGS, 6/14-5/19, $9.4M, 1 of 3 PIs

REU Supplement to Wyoming King Air as a National Facility, NSF-AGS, 5/15-6/15, 7.2K, PI

The Convection Precipitation Experiment – Microphysical and Entrainment Dependencies, NSF-AGS, 1/13-12/16, 733K, co-PI

Geerts:

Dynamical processes of orographic cumuli II, NSF-ATM, 10/09-9/13, $476K, PI

Climate simulations of seasonal precipitation and snow accumulation patterns in the NC region, North-Central Climate Science Consortium, 10/12-9/13, $164K, co-PI

The cloud microphysical effects of ground-based glaciogenic seeding of orographic clouds: new observational and modeling tools to study an old problem, NSF-AGS, 8/11-7/16, $569K, PI

Collaborative research: The kinematics, microphysics and dynamics of long-fetch lake-effect systems in OWLeS, NSF-AGS, 8/13-6/16, $474, PI

Research Capacity Building using a new Dual-frequency Airborne Radar System in support of NASA GPM and ACE Validation Experiments, NASA-EPSCoR, 9/13-8/16, $750K, PI

PECAN (Plains Elevated Convection At Night): large campaign request (Geerts is lead on the Experimental Design Overview), NSF-AGS, 7/13-7/15, $15K,

Airborne measurements of the nocturnal low-level jet and wave disturbances in the stable boundary layer in PECAN, NSF-AGS, 1/15-12/17, $750K, 1 of 3 PIs

SNOWIE: Seeded and Natural Orographic Wintertime clouds – the Idaho Experiment, NSF-AGS, 9/16-9/18, $797K, co-PI

Liu (since arrival in 2013):

Constraining the Modeling of Dust Aerosol and Climate Impacts Using CALIPSO, CloudSat, and Other A-Train Satellite Measurements, NASA CloudSat and CALIPSO, 2/16-2/19, $450K, PI

Use of remote sensing and in-situ observations to develop and evaluate improved representations of convection and clouds for the ACME model, DOE-OBER, 08/16-07/19, $375K, PI

Improving Predictability of Mixed-Phase Clouds and Aerosol Interactions in the Community Earth System Model (CESM) with ARM Measurements, DOE-OBER, 7/15-7/18, $584K, PI

Wildfires and Regional Climate Variability: Mechanisms, Modeling and Prediction, DOE-OBER, 5/13-4/17, $628K, PI

Developing and Evaluating an Advanced Aerosol Module in GEOS-5 for Data Assimilation and Climate Studies, NASA, 1/13-12/16, $578K, PI

Development of Modal Aerosol Module in CAM5 for Biogeochemical Cycles, DOE-OBER, 4/14-4/16, $104K, PI

Further Enhancement of the Cloud Prediction Capabilities of the GEOS-5 AGCM for Radiative and Aerosol Indirect Effect Studies, NASA, 8/13-8/17, $72K, PI

Interplay between black and brown carbon from biomass burning and climate, EPA, 2/16-2/19, $350K, Co-PI (Shane Murphy, PI)

Murphy:

Interplay between black and brown carbon from biomass burning and climate, EPA STAR, 2/16-2/19, $350K, PI

Reconciling top-down and bottom-up greenhouse gas and air pollutant emission estimates from unconventional gas development, DOE, 9/14-9/16, $142K, co-PI

Quantification of Methane and Volatile Organic Compound (VOC) Emissions in the UGR Basin, Clean Air Task Force, $75K, co-PI.

Participation in Flame-IV: Understanding Aerosol Absorption in Biomass

Burning Plumes Through Measurements of Single-Particle SSA, Coatings, and Brown Carbon, NSF, 10-12-10/14, $239K, PI

Development of new particle size spectrometer for rugged deployments in the Antarctic, tropics and mid-latitudes: Measurements from the surface to the stratosphere, NSF, 6/12-/15, $578K, co-PI

Measurements of Aerosol Chemistry during Wintertime High-Ozone Events, NSF, 1/12-11/12, $29K, PI

Parish:

Lidar and Modeling Applications from the PreAMBLE Dataset, NSF-AGS, 2/15-1/17, $175K, PI

Airborne measurements of the nocturnal low-level jet and wave disturbances in the stable boundary layer in PECAN, NSF-AGS, 1/15-12/17, $750K, 1 of 3 PIs

Precision Atmospheric Marine Boundary Layer Experiment (PreAMBLE), 5/11-5/14, $362K, PI.

Rodi:

Wyoming King Air as a National Facility, NSF-AGS, 6/14-5/19, $9.4M, Lead PI

Snider:

Instrumentation for Improved Precipitation Measurement in Wintertime Snowstorms, USGS and WWDC, 3/11-3/13, $71K, PI

EAGER: Collaborative Research: Chilean Coastal Orographic Precipitation Experiment Pilot Project (CCOPE-2015), NSF-AGS, 4/15-4/17, $51K, co-PI

Exploiting synergies between remote sensing and in situ measurements during ICE-T to better understand ice generation in tropical clouds, NSF, 12/10-11/14, $538K, co-PI

Wang:

Developing New Airborne Cloud, Aerosol and Water Vapor Observation Capabilities by Synergizing Remote Sensors and in Situ Probes on the University of Wyoming King Air, NSF-CAREER, 5/07-4/13, $587K, PI

Study Global Mixed-phase Cloud Properties by Combining CloudSat Radar, CALIPSO Lidar, and MODIS Measurements, NASA, 9/10-12/13, $518K, PI

Collaborative Research: Colorado Airborne Multi-Phase Cloud Study (CAMPS), NSF, 5/10-4/14, $179K, PI

Wyoming King Air as a National Facility, NSF-AGS, 6/14-5/19, $9.4M, 1 of 3 PIs

Exploiting synergies between remote sensing and in situ measurements during ICE-T to better understand ice generation in tropical clouds, NSF, 12/10-11/14, $538K, co-PI

CloudSat Level 2 Radar-only (2B-CLDCLASS) and Combined Radar-Lidar

(2B-CLDCLASS-LIDAR) Cloud Scenario Classification Standard Product Improvement and Validation and the Enhanced Ice Microphysical Product Development., NASA-JPL, 4/05-9/15, $1.46M, PI

CloudSat Level 2 Radar-only (2B-CLDCLASS) and Combined Radar-Lidar (2B-CLDCLASS-LIDAR) Cloud Scenario Classification Standard Product Improvement and Validation and the Enhanced Ice Microphysical Product Development, NASA-JPL, 10/15-9/16, $150K, PI

Airborne measurements of the nocturnal low-level jet and wave disturbances in the stable boundary layer in PECAN, NSF-AGS, 1/15-12/17, $750K, 1 of 3 PIs

Improving Mixed-phase Cloud Parameterization in Climate Model with the ACRF Measurements, DOE, 9/11-8/16, $538K, PI

Research Capacity Building using a new Dual-frequency Airborne Radar System in support of NASA GPM and ACE Ground Validation Experiments, NASA-EPSCoR, 9/13-8/16, $750K, co-PI

Mixed-phase cloud property and process study with CloudSat, CALIPSO and other A-train measurements, NASA, 8/13-8/16, $521K, PI

Development of a Multi-function Airborne Raman Lidar (MARLi) for Atmospheric Process Studies, NSF-MRI, 9/13-8/16, $1.72M, PI

Improving Predictability of Mixed-Phase Clouds and Aerosol Interactions in the Community Earth System Model (CESM) with ARM Measurements, DOE, 6/15-5/18, $560K, co-PI

iv. Grants submitted by academic personnel: Previous 5 years

In addition to the successful proposals listed above, current faculty have submitted to the following external agencies proposals that were unsuccessful:

DOE – 6
NASA – 4
NOAA – 2
NSF - 14
UAE - 2

v. Publications/presentations by academic personnel

Note: Only refereed publications listed

Five Year (2012-2016) Summary ~175 refereed publications

(Detailed list of faculty refereed publications is attached Appendix ii)

vi. National/international awards

Xiaohong Liu named to the list "Highly Cited Researchers" by Thomson-Reuters, 2014; 2015

vii. Other

University of Wyoming Technology Transfer

Spin Off Company developed: Alpenglow Instruments. DOE SBIR grant received. Atmospheric Science personnel include Perry Wechsler, Zhien Wang, Nick Mahon and Dave Leon.

The Atmospheric Science Department has long been a national and international leader in the development, integration and deployment of atmospheric instrumentation. This has included development of the first airborne computerized data acquisition system, early development and deployment of cloud spectrometers, particle imaging probes and the development of airborne Cloud Condensation Nuclei Counters (CCNC). More recently, the department has led the development of remote sensing instruments including the Wyoming Cloud Radar (WCR) and Wyoming Cloud Lidar (WCL), both of which are now part of the Wyoming King Air aircraft NSF national facility and the newly-developed Multifunction Airborne Raman Lidar (MARLi). In several cases there has been demand from other research institutions to purchase versions of instruments developed in house..

Alpenglow Instruments LLC, founded by Professor Zhien Wang, Mr. Perry Wechsler and Mr. Nick Mahon in 2013, embodies the collaboration between science and engineering central to the success of the Atmospheric Science Department. Presently located in the Wyoming Technology Business Center (WTBC), Alpenglow Instruments has built, sold and installed two Airborne Elastic Cloud Lidars (AECL) and has just received an order for a third system. In addition, Alpenglow Instruments has received a SBIR Phase 1 grant from the Department of Energy to develop a Raman scattering based all-phase water probe, which leverages departmental expertise in both remote sensing (specifically the development of MARLi) and in the development of in situ probes for airborne atmospheric research. Alpenglow anticipates revenue approaching $500,000 for 2016 and is currently preparing a SBIR Phase 2 commercialization proposal, which could culminate in grant funding of up to $2 million.

High tech spin-off companies, such as Alpenglow Instruments, are an example of how University of Wyoming investments in research can be leveraged into potentially major benefits to the state economy. Alpenglow CEO Perry Wechsler, a Senior Research Scientist in the UW Department of Atmospheric Science, expects the company to grow to 5-10 employees in the next two years. The close association and support from the University of Wyoming, the Department of Atmospheric Science and the WTBC has been critical to the success of this small, high tech business.

c. Program reputation

   i. If program is ranked, include rank and by what organization.

      University of Wyoming graduate programs were not included in the most recent (2010) National Research Council report (in which Atmospheric Science programs were reviewed).

   ii. Include a brief description of any other indicators of program reputation such as demand (e.g. waiting lists or over enrollment) for admission into program, employer data/feedback, etc.

      The Department of Atmospheric Science supports the University of Wyoming King Air research aircraft facility though a Cooperative Agreement with the National Science Foundation. The origin of this NSF agreement reaches back to the 1980s. We are now working on the Seventh Cooperative Agreement with NSF. As part of the Cooperative Agreement, the University of Wyoming King Air is an NSF National Facility that serves researchers in the U.S. and abroad with a platform capable of monitoring atmospheric conditions in the lower troposphere. Of all NSF Lower Atmosphere Observing Facilities (an array of ~20 aircraft, radars, sounding and surface systems across the nation), the UWKA has been requested and deployed the most, with a total of 50 deployments in the last two decades (1992-2015; Avallone and Baeuerle 2016). As such it has maintained a high visibility within the research community as demonstrated by its role in large field projects during the past three decades. Most recent deployment of note is in support of the Plains Elevated Convection Experiment, a large multi-agency effort during the summer of 2015 (e.g., http://www.pecan15.org/home/; http://www.nssl.noaa.gov/projects/pecan/; https://www.eol.ucar.edu/field_projects/pecan)

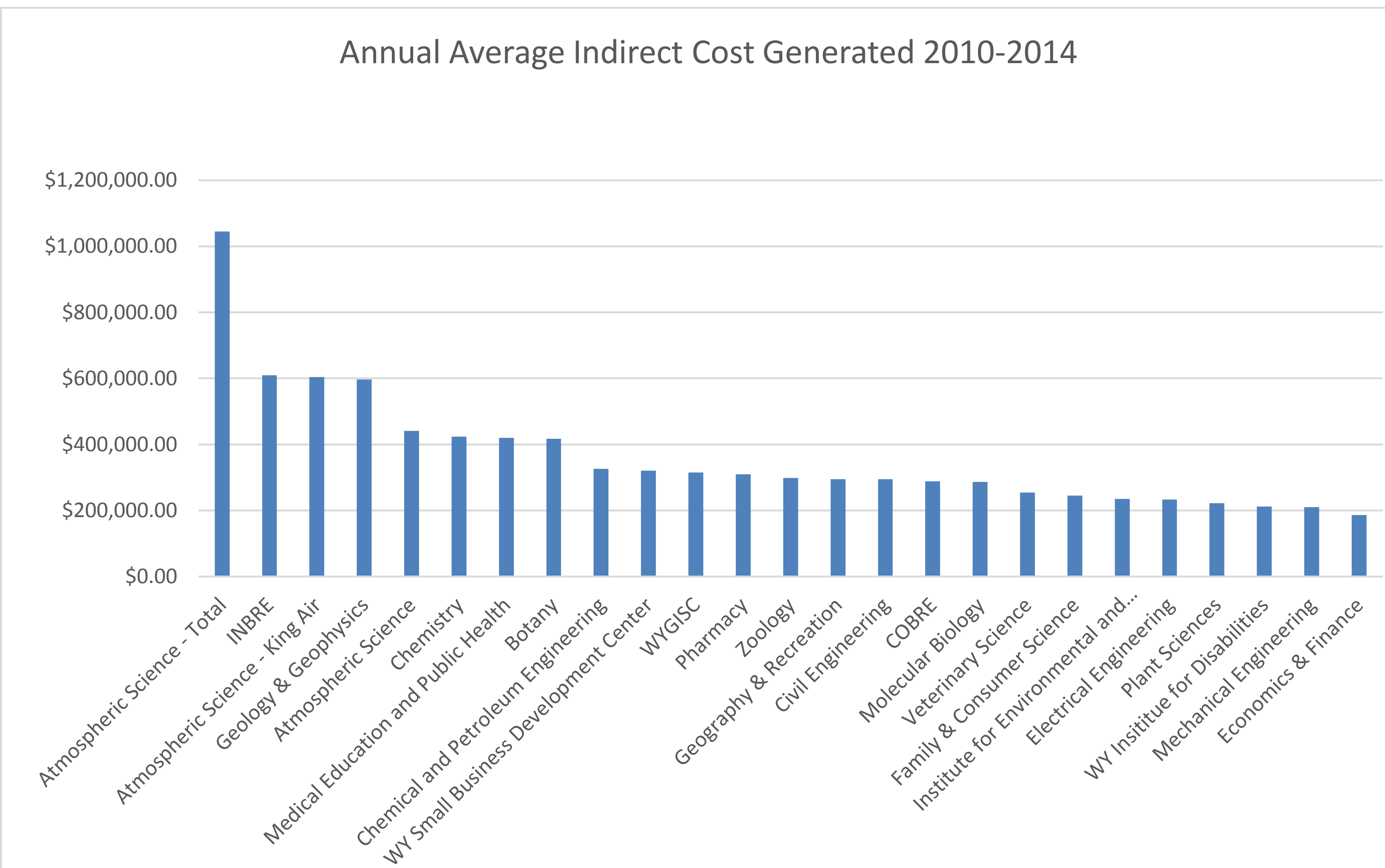
      Avallone, L., and B. Baeuerle, 2016: A 20-year history of NSF-supported atmospheric science field campaigns: statistics and demographics. Bull. Amer. Meteor. Soc, in review.

      (Note: Dr. Avallone is the NSF Program Manager in charge of the Lower Atmosphere Observing Facilities (LAOF) of which the University of Wyoming King Air is part.)

      Aircraft measurement capabilities include in-situ sampling of precipitation physics, atmospheric dynamics, air chemistry and aerosols and extensive remote sensing capabilities. State-of-the-art instrumentation has been designed and developed within the Atmospheric Science group including the Wyoming Cloud Radar (WCR), the Wyoming Cloud Lidar (WCL) and the recent Multi-function Airborne Raman Lidar (MARLi). Both the WCR and the WCL are NSF National Facilities that have been routinely utilized by the Atmospheric Science community.

The Department of Atmospheric Science has consistently been one of the top users of the NCAR-Wyoming Supercomputing Center (NWSC), which is located in Cheyenne. As part of the Wyoming-NCAR Alliance, the university receives approximately 75 million core-hours per year. For the past June 2016 competition, a total of 42.6 million core hours were awarded to 9 projects led by the University of Wyoming faculty members. Professor Liu's group received 25.3 million core hours, or approximately 60% of the total university's allocation for that period. These resources are used to advance our understanding of climate and cloud systems using novel numerical modeling techniques and high-resolution simulations.

The Department of Atmospheric Science has routinely been one of the most productive research departments at the University of Wyoming with research expenditures around $4M per year. Indirect cost returns to the University of Wyoming from Atmospheric Science research activity are the largest on campus. For the years 2010-2014, the Department of Atmospheric Science was responsible for an average of $1.1M in indirect costs returned to the University of Wyoming. This compares to the total state support for the Department of Atmospheric Science of (as of 7/1/2016) $1.004M. A depiction of the yearly-average indirect cost returns by key department/units on campus for the five-year period 2010-2014 is shown below.



d. Curriculum of major or specialization
    i. Include a list of courses by prefix, number, title required in the major or specialization (do not include general education course unless required as part of the major requirements.)

    The Department of Atmospheric Science curriculum has been reconfigured for the 2015-2016 academic year based in part on responses from former students as part of a recent Program Assessment. Required classroom and software skills after graduation were addressed as part of the survey. In addition, program outcomes included meeting requirements for M.S. graduates to attain proficiency required for General Schedule Qualification Standards Meteorology Series, 1340 (to be eligible for consideration for federal civil service meteorological positions - the National Weather Service).

    Atmospheric Science Core Curriculum (incoming M.S.-level students)

    Year 1 – Fall Semester
    ATSC 5010 – Physical Meteorology I (4 credits)
    ATSC 5014 – Dynamic Meteorology (4 credits)
    ATSC 5018 – Ethics and Research Methods (1 credit)

    Year 1 – Spring Semester
    ATSC 5011 – Physical Meteorology II (4 credits)
    ATSC 5014 – Synoptic and Mesoscale Meteorology (4 credits)

    Year 2 – Fall Semester
    ATSC 5040 – Climate Science and Climate Change (3 credits)
    ATSC XXXX – Atmospheric Science elective class (3 credits)

    Year 2 – Spring Semester
    ATSC XXXX – Atmospheric Science or outside elective class (3 credits)

    A total 26 formal classroom credits is required for the M.S. degree. For the Ph.D. degree, 42 formal classroom credits is required. The individual Program of Study will vary depending on research focus. Development of the actual course schedule rests with the examining committee.

e. Distance delivery of program/major *(N/A)*
    i. Note if the program is offered online and/or at one of the off-campus attendance centers (e.g., UW-Casper)

f. Quality of Assessment Plan/data
    i. Include a brief description of the program assessment plan and how the data are used to inform decisions related to program quality and student learning.

We have taken a more aggressive approach to program assessment during the past two years. A survey was circulated to former students of the past 10 years to assess appropriate skill set and software to prepare for careers. This has prompted changes in the curriculum that were implemented in Fall Semester 2015. We have found as part of that assessment that nearly all former students are employed in a field that is directly tied to atmospheric science. Current assessment document for the Ph.D. program submitted on 15 July is attached as Appendix iii.

g. Strategic Plan

  i. Include a brief description of any plans for the program or specialization that appear in the college/department strategic plan (i.e., facilities upgrades, curriculum changes, on-line or off-campus delivery, enrichment learning opportunities, etc.)

Atmospheric Science has identified three areas for program development:

1. ***increase research aircraft lifespan***
2. ***increase graduate degrees granted***
3. ***increase student credit hours taught by department faculty***

Research Aircraft: *Our central focus from the previous year is to replace our current aircraft. Extensive research and planning was conducted to identify the next aircraft and a plan of funding was put in place. The state legislature agreed to a loan for the purchase, with payments to be from departmental income. An aircraft purchase agreement was signed and delivery was expected in June 2016. The agreement was cancelled by UW due to budget factors in April. To continue work with our current N2UW aircraft we have hired a consultant to reassess the lifetime of the airframe therefore allowing us move forward with our research.*

Degrees Granted: *A second major focus is to increase the number of graduate students in our program and to increase the M.S. and Ph.D. production rates. The department is taking steps to increase the number of degrees granted to be proportional to the research dollars brought into UW. This effort was initiated two years ago and the number of enrolled graduate students has increased from 19 in 2012 to an expected 32 in the Fall Semester 2016, all of them with graduate assistantships, but only one with a state GA. This increase in the number of graduate students results from concerted efforts to increase number of admitted students into our program through improved recruitment efforts and to recruit higher caliber graduate students leading to higher retention rates. The recent increase in the number of students recruited and retained has occurred during a time when the number of state-funded GA's within the department has decreased from 3 to 1. The Department of Atmospheric Science has had a solid record in terms of acquiring research funds. As part of meetings between faculty members and the Department Head and as part of the College of Engineering and Applied Science's annual review process, goals are established in terms of teaching expectations and* *research productivity. A goal for graduate student enrollment has been established to increase the number to approximately 40 in the next two years. A further goal is to reduce the effective time-to-degree for M.S. students to four semesters. This is accomplished by changes in the course curriculum and changes in the transition from M.S. to Ph.D. status. The net result of the increased enrollment and decreased time-to-degree is a significant increase in number of degrees offered: we expect a doubling of graduate degrees in the next five years, compared to the last five years. Finally, we plan to continue to increase the Ph.D.:M.S. ratio, consistent with UW's aspiration to maintain its Carnegie Foundation Research Universities — High Research Activity (RU/H) status*

Student Credit Hours Generated by Teaching: *A third area of focus is on education. Metrics compiled by Associate Dean Paul Dellenback showed low student credit hours taught by the Atmospheric Science faculty. This deficiency was immediately addressed in the Spring Semester 2016 faculty meeting. In academic year 2015-2016, the Department of Atmospheric Science taught a total of 940 student credit hours. A two-year goal is to double that number. This effort is also in line with President Nichol's vision of enhancing faculty teaching loads.*

To meet this goal, three strategies have been put in place commencing in academic year 2016-2017. First, a series of undergraduate courses is being developed to serve the university community. Those courses include First Year Seminar course ATSC1101 (Weather, Climate and Global Change) and ATSC 2100 – Global Warming. Both will be taught during the Fall Semester 2016. Currently under development are courses in Atmospheric Chemistry (primarily for Atmospheric Science graduate students although thought to be of use for students in Chemical Engineering) and an undergraduate survey course in Severe Weather. Assistant Professor Zach Lebo is spearheading the latter effort based on a similar course at Penn State University where he did his B.S. and M.S. work. All such courses will be approved PN courses under the new USP 2015. Given changes in the USP 2015 curriculum (i.e., no required laboratory sections), it will be possible to service large sections of these courses. The ATSC 2100 (Global Warming) course, in particular, has been targeted for growth given the compelling and controversial issues surrounding the science of global change.

A second strategy is to double our service to the Engineering Science program. We have taught Engineering Science courses for the past 35 years. Recently one large section has been serviced by Atmospheric Science faculty each semester in either ES 2110 (Statics), ES 2120 (Dynamics) or ES 2310 (Thermodynamics). We will double that effort in Academic Year 2016/17. Dr. Robert Kelly will teach a large section (~80 students) of ES 2110 and Dr. Jefferson Snider will teach a large section of ES 2310. In the spring, Drs. Kelly, Parish and Snider will teach separate sections of ES.

A third strategy will be to increase the teaching of elective courses in Atmospheric Science to our growing M.S. and Ph.D. crop of students. Our goal is to increase student credit hours taught per faculty member to be comparable to other units within the College of Engineering and Applied Science.

h. Other:

3. **Mission Centrality: Does the program advance the mission of UW including institutional strategy?**
   a. Describe how the program supports the mission, vision and strategic goals of UW.

   University Plan 4 remains in draft phase so reference is made to University Plan 3. Critical areas of science and technology are listed on page 1, including "earth and energy sciences and technology" and "water resources." Research in the Department of Atmospheric Science encompasses those areas. Recent NSF research grants include assessment of enhancement of increasing mountain snowpack by cloud seeding, the first such funded NSF research on weather modification in nearly 30 years. The Department of Atmospheric Science has a long history in studies of the precipitation process of the high western landscape.

   As part of the Tier 1 Engineering Initiative, Atmospheric Science was highlighted as a "niche area of excellence at UW". The "Atmospheric Science program is viewed as a model for developing sustained niches of excellence in graduate education." In reference to the Department of Atmospheric Science, the Tier 1 reports concludes, "the depth of faculty resources, coupled with valuable assets unique to UW and the state, provide a formula for lasting excellence that we intend to emulate in other niche areas" (see the University of Wyoming Engineering Initiative: Toward Tier 1 for Wyoming report http://www.uwyo.edu/acadaffairs/plans/uw_engineering_initiative_may_13.pdf).

   b. Describe how the program contributes to other programs across campus (i.e., general education courses, minor or support courses, interdisciplinary program, etc.)

   The Department of Atmospheric Science offers undergraduate courses to the university community in general meteorology (ATSC 2000) and issues and the science associated with global warming (ATSC 2100).

   During the past decade an attempt was made to provide an interdisciplinary undergraduate degree in Earth System Science, in collaboration with several departments from two other colleges. The atmospheric science concentration for the program did not attract sufficient student numbers, however, and was discontinued in 2014.

   c. Include placement data for graduates and indicate if graduates are working in the field or not.

A recent survey was sent to former graduates as part of the assessment process. Data collected indicated that all our graduates were working in the atmospheric science area. As part of our assessment process, we are working to update our contact information to enable a more complete and statistically-significant analysis.

d. Describe the uniqueness or duplication of this program across the UW.

The Department of Atmospheric Science holds a unique niche at the University of Wyoming. It houses research as well as transportation flying for the University of Wyoming. Research activities conducted by faculty and staff within Atmospheric Science focus on aspects of the precipitation process and other related issues have been the hallmark of this group for five decades. This allows students to acquire first-hand experience in collecting data that is used in their research. Given the strong observational nature of our program, students acquire unique experience in instrumentation development/testing, statistical methods, and critical analysis.

During the past two years, we have expanded our research/teaching activities to the modeling of climate, clouds and precipitation, a critical component of atmospheric sciences for predicting future climate changes.

There is a clear need for such programs (Serafin et al. 1991; Takle 2000), and in fact a continued concern that graduates in atmospheric sciences lack training in hands-on atmospheric technology (Horel et al. 2013).

Horel, J. D., D. Ziegenfuss, and K. D. Perry, 2013: Transforming an atmospheric science curriculum to meet students' needs. Bull. Amer. Meteor. Soc., ***94****, 475–484.*

Serafin, R., B. Heikes, D. Sargeant, W. Smith, E. Takle, D. Thomson, and R. Wakimoto, 1991: Study on observational systems: A review of meteorological and oceanographic education in observational techniques and the relationship to national facilities and needs. Bull. Amer. Meteor. Soc., ***72****, 815–826.*

Takle, E., 2000: University instruction in observational techniques: Survey responses. Bull. Amer. Meteor. Soc., ***81****, 1319–1325*

e. Other:

4. **Cost: Is the program financially viable?**

a. Ratio of student credit hours per FTE

During FY 2015, Atmospheric Science faculty taught 938 student credit hours. From the 2016 Budget Index, Atmospheric Science has 8.674 FTE faculty lines.

Our ratio of student credit hours per FTE of 108 student credit hours in FY 2015 has been targeted for improvement. As discussed earlier, we will introduce three new *undergraduate courses including a First Year Seminar class during the next academic year and double our Engineering Science participation.*

b. Direct instructional expenditures:

Current State of Wyoming support for faculty in the Department of Atmospheric Science is $969,779. Using a five-year average as discussed above, 4.8 M.S degrees and 1.6 Ph.D. degrees were granted per year.

i. Per student credit hour
$1034/student credit hour

ii. Per total degrees awarded
$151,528/graduate degree granted

iii. Non-personnel expenditures per total academic FTE

c. Course enrollment

i. Number of classes falling under University minimums
During the past academic year we had three classes taught at the undergraduate level that did not meet minimums. These classes were offered to allow the final Earth System Science students to graduate.

ii. Lower-division courses falling under University minimums - *See above*

d. Other instructional cost drivers, such as:

i. Section fill rates
Given the graduate nature of our department, fill rates are zero.

ii. Course completion rates
We have routinely 100% course completion rates, again not significant given our graduate status.

iii. Curricular complexity
Mostly standard classroom situations. Lab components as part of our revised curriculum are more demanding with computer-related exercises and numerical modeling requirements.

iv. Faculty course load
Prior to recent changes in course loads, our typical teaching loads were 2/1 for nearly all faculty.

e. Research expenditures per tenured/tenure-track FTE (and other academic personnel, where appropriate)
During FY 2016, our research expenditures amounted to $3.72 M. We have 8.674 FTE faculty corresponding to $429,000 per tenured/tenure-track FTE. This is comparable to the National Research Council top-ranked Atmospheric Science departments in the U.S.

f. Compare your data to national benchmarks (Delaware data)
Our ratio of student credit hours per FTE is a weakness but our research productivity compares with highly productive departments at major research institutions as noted in the above Engineering Tier I report.

Appendix i: List of Ph.D. Graduates (Fall 2011-Summer 2016)

Thomas Andretta, Ph.D. Fall 2011 (Geerts)

Yonggang Wang, Ph.D. Spring 2012 (Geerts)

Mahesh Kovilkam, Ph.D. Summer 2012 (Deshler)

Damao Zhang, Ph.D. Fall 2012 (Wang)

Loknath Adhikari, Ph.D. Fall 2012 (Wang)

Patrick Campbell, Ph.D. Summer 2013 (Deshler)

David Reed, Ph.D. Spring 2014 (Kelly)

Binod Pokharel, Ph.D. Fall 2014 (Geerts)

Current Ph.D. Students and expected completion date

Phillip Bergmaier, Fall 2017 (Geerts/Wang)

Xia Chu, Fall 2016 (Geerts)

Rachel Edie, Spring 2019 (Murphy)

Katherine Foster, Spring 2018 (Murphy)

Xiaoqin, Jing, Fall 2017 (Geerts)

Tim Juliano, Fall 2018 (Parish/Lebo)

Sujan Khanal, Summer 2017 (Wang)

Rudra Pokhrel, Summer 2017 (Murphy)

Stefan Rahimi, Spring 2018 (Liu)

Anna Robertson, Spring 2019, (Murphy)

Adam Tripp, Spring 2019 (Geerts)

Jing Yang, Spring 2017 (Wang)

Appendix ii: List of faculty peer-reviewed publications (2012-2016)

Deshler:

Deshler, T., In situ observations of volatile and non-volatile particle size distributions from balloon-borne platforms, a chapter in *Volcanic ash: Methods of observation and monitoring*, Elsevier in press.

Kremser, S., L.W. Thomason, M. von Hobe, M. Hermann, T. Deshler, C. Timmreck, M. Toohey, A. Stenke, J. P. Schwarz, R.Weigel, S. Fueglistaler, F. Prata, J-P. Vernier, H. Schlager, J. Barnes, J-C. Antuña-Marrero, D. Fairlie, M. Palm, E. Mahieu, J. Notholt, M. Rex, C. Bingen, F. Vanhellemont, A. Bourassa, J. M. C. Plane, D. Klocke, S. A. Carn, L. Clarisse, T. Trickl, R. Neely, A. D. James, L. Rieger, J. C. Wilson, and B. Meland, (2016), Stratospheric aerosol - Observations, processes, and impact on climate, Rev. Geophys., in press

Kovilakam, M., and T. Deshler (2015), On the accuracy of stratospheric aerosol extinction derived from in situ size distribution measurements and surface area density derived from remote SAGE II and HALOE extinction measurements, *J. Geophys. Res.*, 120, 8426–8447, doi:10.1002/2015JD023303.

Di Liberto, L., R. Lehmann, I. Tritscher, F. Fierli, J. L. Mercer, M. Snels, G. Di Donfrancesco, T. Deshler, B. P. Luo, J-U. Grooß, E. Arnone, B. M. Dinelli, and F. Cairo (2015), Lagrangian analysis of microphysical and chemical processes in the Antarctic stratosphere: a case study, *Atmos. Chem. Phys., 15*, 6651–6665.

Deshler, T., (2015) Observations for Chemistry (In Situ): Particles, *Encyclopedia of Atmospheric Science*, Academic Press.

Ritzman, J. M., T. Deshler, K. Ikeda, R. Rasmussen (2015), Estimating the fraction of winter orographic precipitation produced under conditions meeting the seeding criteria for the Wyoming weather modification pilot project, *J. Appl Met. Clim., 54,* 1202-1215.

Dhomse, S S, K. M. Emmerson, G. W. Mann, N. Bellouin, K. S. Carslaw, M. P. Chipperfield, R. Hommel, N. L. Abraham, P. Telford, P. Braesicke, M. Dalvi, C. E. Johnson, F. O'Connor, O. Morgenstern, J. A. Pyle, T. Deshler, J. M. Zawodny, and L. W. Thomason, (2014), Aerosol microphysics simulations of the Mt. Pinatubo eruption with the UM-UKCA composition-climate model, *Atmos. Chem. Phys., 14*, 11221–11246.

Ridley, D. A., S. Solomon, J. E. Barnes, V. D. Burlakov, T. Deshler, S. I. Dolgii, A. B. Herber, T. Nagai, R. R. Neely III, A. V. Nevzorov, C. Ritter, T. Sakai, B. D. Santer, M. Sato, A. Schmidt, O. Uchin, and J. P. Vernier *(*2014*),* Total volcanic stratospheric aerosol optical depths and implications for global climate change, *Geophys. Res. Lett.*, *41*, 7763–7769, *doi:* **10.1002/2014GL061541**.

Breed, D., R. Rasmussen, C. Weeks, B. Boe, and T. Deshler (2014) Evaluating winter orographic cloud seeding: Design of the Wyoming weather modification pilot project (WWMPP), J. Appl. Meteor. Clim., 53, 282-299.

Campbell, P., M. Mills, *and* T. Deshler *(*2014*)*, The global extent of the mid stratospheric CN layer: A three-dimensional modeling study, *J. Geophys. Res. Atmos.*, *119*, doi:*10.1002/2013JD020503*.

Ward, S. M., T. Deshler, and A. Hertzog (2014*)*, Quasi-Lagrangian measurements of nitric acid trihydrate formation over Antarctica, *J. Geophys. Res. Atmos.*, *119*, doi:*10.1002/2013JD020326*.

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Appendix iii – Draft of Ph.D. Assessment Plan Summer 2016

Assessment of Student Learning Outcomes Report

Department or program name: Atmospheric Science

Name of degree/program assessed:

Program Level (check one):

________ Undergraduate

________ Masters

___X____ Doctorate

Submitted by: Assessment Committee, Department of Atmospheric Science (Thomas Parish, Charlotte While, Jefferson Snider, Zachary Lebo)

Date submitted: July 5, 2016

1. **Please reflect on your program's assessment process and feedback provided by the University Assessment Coordinators Committee last year. What did you change or do differently with regards to your assessment processes? Provide at least two concrete examples. (<u>If you did not submit a report last year, please indicate this.</u>)**

This year (2016) is the first year for which we are submitting an assessment of our doctoral program. Last year we submitted a generic graduate assessment form that included elements of the Ph.D. program. Feedback from the instrument of last year indicated a lack of specific student learning objectives and a process by which those objectives were evaluated. In response to this, a committee was formed to focus on assessment of learning objectives at both the M.S. and Ph.D. levels. The committee consists of Department Head Thomas Parish, Charlotte While, Jefferson Snider and Zachary Lebo. A list of student learning objectives was developed and circulated. Findings from that review were incorporated in the list of learning objectives presented in the next section.

2. **Do you have student learning outcomes for your degree/program? If yes, please list them here. (Please note that student learning outcomes for your graduate program should be different from those you may have for your undergraduate program since a higher level of learning would be expected.)**

All students in Atmospheric Science will first write a Plan A M.S. thesis or had an equivalent M.S.-level experience elsewhere with a thesis written in English. Goals of the M.S. program are listed in the companion document for the M.S. Assessment Report. Ph.D. studies will include those M.S. goals as well as the following:

PhD Degree:
The Ph.D. degree is awarded upon attainment of independent scholarship in atmospheric science. This accomplishment is demonstrated by the ability to conduct scientific discourse across a wide range of disciplines within the science, and the ability to conduct original research leading to unique contributions in an area of specialization. The Ph.D. program consists of course work, participation in the intellectual life of the department and the university, and development of skills required to pursue independent research. Admission to the Ph.D. program is granted to students who show high promise of sustained effort and dedication to the pursuit of knowledge in atmospheric and related sciences. The Ph.D. program prepares students for carrying out independent research in governmental, academic, or private laboratories, and for teaching at the community college, four-year college or university level. Ph.D. students will have demonstrated:

1) Demonstrate an ability to independently identify relevant scientific problems in the dissertation specialty area.
2) Demonstrate a deep understanding of the literature in the dissertation area.
3) Demonstrate an ability to design methods for observation and experimentation, and evaluate the results of such research.
4) Demonstrate an ability to communicate research results in peer-reviewed journals, and present effective seminar to both on- and off-campus colleagues.
5) Participate in and understand procedures required in preparation and submission of proposals to federal or other granting agencies.
6) Demonstrate an ability to plan course syllabi, and present well-organized and effective lectures for upper division and graduate level education.

3. What discussions have taken place with the faculty regarding assessment of student learning outcomes? Please provide details of the meeting(s) and who was involved.

As part of the previous year, a survey was developed that was emailed to all former graduates of our program. Responses from that survey were used to refine the new curriculum. Questions asked to former students addressed particular software skills that were most applicable beyond the classroom. This has prompted a dialogue regarding what software skills are best applicable to ensure student success within the classroom as well as in the real world. Some have advocated away from proprietary software such as IDL and MATLAB to open source Python. We have encouraged Ph.D. students (though not yet require) development of programming skills in Python. Results were discussed in faculty meetings during which all faculty and key Academic Professional staff (Larry Oolman, Nick Guy) were included.

4. What steps have your department/program taken over <u>the last year</u> to implement your assessment plans (if plans were in place)? Include specific examples such as curriculum mapping or developing tools such as rubrics, development of test questions, surveys, etc. and indicate which student learning outcomes were assessed.

Given the research nature of the Ph.D. degree, assessment in terms of curriculum have been more difficult to define. Extensive work has been conducted at the M.S. level to prepare students to enter the Ph.D. program. In particular, based in part on the student survey, our M.S. core curriculum includes formal presentations, writing of research papers formatted to be submitted to the American Meteorological Society journals. We have discussed requiring all Ph.D. students to present one seminar per year although that decision has not be finalized (address goal #4 in student learning objectives listed above). Further, to evaluate student learning objectives #1, #2 and #3, it has been proposed that the Preliminary Exam be taken within the first year of becoming a Ph.D. student. Previously, this has been subject to the individual committee decision. Dr. Jeff French has prepared a new document that outlines student expectations for the Ph.D. degree that is now posted online.

5. **Do you have any assessment of student learning results to share? If so, please include.**

   What are the plans for your program to improve from Tier 3 to Tier 2 status? What concrete steps will you take next year to improve? Provide timeline and who will be involved. (Go to http://www.uwyo.edu/assessment/annual-reports/ for definitions of each assessment tier).

Faculty discussion has taken place regarding the possibility of students moving directly into the Ph.D. program, thereby bypassing the M.S. degree. Given that metrics are becoming increasingly important, the utility of such a process is currently in question. At the same time, we have arranged our new curriculum to permit students to take the Qualifying Exam, the entrance requirement to becoming a Ph.D. student, after their first year of study.

We offered the Preliminary Exam twice in 2016. Consistent with the document developed by Dr. French, the whole faculty participated in exam development and grading. This process revealed a few topic areas in which many students are deficient. Based on this we will be modifying one of core curriculum courses in Fall 2016 (Physical Meteorology I).

Part II - Recommendations

Instructions: *After the review is completed, the Dean in consultation with the Department Head will select one of the following recommendations. In the justification, address each of the items associated with the recommendation.*

1) **Retain Due to Critical Need**
   a) A college may recommend that a degree program be retained due to its ability to fulfill a critical workforce need or shortage area for the state.

   b) Justification for retaining due to critical need must include:
      i) Explanation of why the program is important to the University/State/region
      ii) Description of specific steps (already taken and/or planned) to increase enrollment and graduate production;
      iii) Preliminary outcomes of steps taken.

2) **Retain with Further Review Required**
   a) A college may request that a program be retained for further review for those degree programs that serve a specific function central to the mission of the college or university.

   b) Justification for retain due to further review must include:
      i) Explanation for how the program is central to the university's mission and the benefit to the system;
      ii) Description of specific steps (already taken and/or planned) to increase enrollment and graduate production;
      iii) Preliminary outcomes of steps taken.

3) **Consolidate with Another Program within College**
   a) A college may request that a program be consolidated with a similar program on campus that achieves similar degree requirements.

   b) Justification to consolidate with another program on campus must include:
      i) Explanation for how the degree requirements for the two programs warrant consolidation;
      ii) Evidence that the consolidation will meet graduate production thresholds, or specific steps to increase enrollment to meet production thresholds;
      iii) Preliminary outcomes of steps taken.

4) **Consolidate with Program(s) between Colleges/campuses (e.g., UW/C)**
   a) Two or more colleges may request that similar degree programs be consolidated to maintain equivalent degree programs.

   b) Justification for retaining due to cross-college consolidation must include:
      i) Explanation for how the consolidated programs will collaborate (e.g., sharing of required courses, shared faculty, etc.) to maintain graduate production thresholds;

ii) Evidence that multi-college collaboration will meet graduate production thresholds, or specific steps to increase enrollment if merging programs fails to meet production thresholds;
iii) Preliminary outcomes of collaboration between colleges.

5) **Terminate**
   a) A college may request that a program be terminated due to limited graduate production, lack of student interest, shifts in a given field of study, or continued declines in major enrollments.
   b) If the exigency for termination results from the program productivity review process then a brief justification to terminate a program should be included. Such a justification must include:
      i) Explanation for the decline in graduate production in the degree program;
      ii) Intended timeframe for submitting a program termination request to the Board of Trustees for their consideration;
      iii) Expected timeline to meet teach-out requirements established through the regional accrediting body.

APPENDIX A

"Low Productivity" Programs Excluded from Review Process

1) **Major Program Modifications**
   a) Degree programs that have undergone recent program modifications that adversely impact graduate production for a college.
   b) Modifications traditionally include programs that have undergone recent name changes during the reporting window that result in two equivalent degree programs.

2) **Program/Major Specializations**
   a) Degree programs that have one or more specializations which reduce the total number of graduates.
   b) The exclusion may apply only for those specializations where the combination results in graduate production that meets the establish threshold for the degree.

3) **Terminated Programs**
   a) Degree programs that have been inactivated during the reporting period, but still depict graduates that fall below the established thresholds.
   b) Terminated programs will remain on the Program Productivity Report until inactive programs have completely cycled through the established reporting period.

4) **New Programs**
   a) Degree programs that have been activated within the past 7 years resulting in limited graduate production due to program implementation.
   b) Institutional review may be requested prior to the 7^{th} year if graduate production is not scaling to the required thresholds for the degree level.

NCAR

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July 18, 2016

To whom it may concern,

I am the current Chief Scientist of the Community Earth System Model (CESM) and also a Senior Scientist at the National Center for Atmospheric Research (Boulder, CO) with a joint affiliation in the Atmospheric Chemistry Observations and Modeling (ACOM) and Climate and Global Dynamics (CGD) Laboratories. I received my Ph.D. in Physics from the Catholic University of Louvain (Belgium) in 1993 and have been at NCAR since, except for one year at NOAA. I was a lead author in the recent Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment Report (AR5). Most of my research focuses on global modeling of chemistry-climate interactions, with a specific emphasis on tropospheric chemistry.

I have worked extensively with Prof. Xiaohong Liu over the last 7 years or so and I am delighted that he joined the University of Wyoming approximately 3 years ago. The physical proximity and the high quality of Xiaohong's work has been instrumental in building the next generation of Earth System models, with such effort to culminate in the upcoming release of the CESM version 2.0 later this year. Earth System models rely on the incorporation of our best understanding of the main processes governing the physics, chemistry and biology of the climate system. In the case of Xiaohong's research, this is very specifically targeting the representation of aerosol particles, and their interactions with clouds and impacts on the climate system. This is a key area for any Earth System model that aims at representing the climate evolution over the last century and into the future. The ability of accurately representing those processes has put CESM at the forefront of Earth System models and allows scientists around the world to use this model to answer societally-relevant questions. Xiaohong and his team have made significant contributions to CESM over the years and I am looking forward to furthering his involvement and input to CESM.

Let me know if you need further information. Sincerely,

J. F. Lamarque

Dr. Jean-François Lamarque
Senior Scientist

Joyce E. Penner
Ralph J. Cicerone Distinguished University Professor of Atmospheric Science

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July 19, 2016

To whom it may concern:

I am writing this letter to express my support for the University of Wyoming Department of Atmospheric Science. I am the Ralph J. Cicerone Distinguished University Professor of Atmospheric Science. I am currently the President-elect of the Atmospheric Sciences section of the American Geophysical Union, and also the Vice-President of the International Association of Meteorology and Atmospheric Science. I am also Co-Chair of National Academy of Sciences Committee on Earth Science and Applications from Space, which serves under their Space Study Board. My closest colleague within the department is Professor Xiaohong Liu although I also am familiar with the work of Professor Jeff Snider. Professor Liu was also a postdoctoral scholar with me at the University of Michigan during 2000 and 2001 and thereafter became a research scientist (2002 – 2005).

He, of course, went on from these positions to work at the Pacific Northwest National Laboratory (2006 – 2013) and then to become a Professor in the afore mentioned department as well as the Wyoming Excellence Chair in Climate Science.

Xiaohong has become an important figure in atmospheric science, leading the Department of Energy's Ice Nucleation Working Group within their Atmospheric Science Research Program. He has also recently accepted a position as leader of the National Center for Atmospheric Research Community Earth System Model Atmospheric Chemistry Working Group. These are both important leadership positions, and they complement his work and leadership with the AeroCom Project, an international group formed to understand the diversity of results associated with the climate impacts of aerosols.

These leadership positions require time and effort and to which Professor Liu has diligently applied himself, with the support of the Atmospheric Science Department. While doing this work, he also fulfills his academic requirements at the university, having overseen the work of 21 graduate students and postdoctoral candidates.

Professor Liu is an asset to the University of Wyoming, and his work helps to increase its visibility both nationally and internationally. He, and the Department, deserve the highest level of support.

Sincerely,

Joyce E Penner

Joyce Penner, Ralph J. Cicerone Distinguished University Professor of Atmospheric Science