Department of Meteorology and Atmospheric Science Strategic Plan 2020-2024

Mission Statement:

The Department of Meteorology and Atmospheric Science expands the reaches of the atmospheric sciences, prepares students for emerging careers, and advances the well-being of the University and society.

Values:

- Scientific integrity
- Dedication to teaching, research, and service
- Innovation in academics and research
- Collaboration and collegiality in all that we do

Vision:

> To have world-renowned excellence in meteorology, atmospheric science, and climate science research and teaching, attracting the best and brightest students, and influencing decisions related to weather and climate.

Introduction:

Faculty and students in the Department of Meteorology and Atmospheric Science – where weather and climate meet - are ideally suited to address many of the major environmental challenges facing the world today. This ability is founded upon the tremendous breadth and depth of faculty expertise, the productive collaborations and the talent, energy, and drive of our faculty and students. Our contributions to weather and climate science have had a positive impact on the lives of people across the commonwealth, nation, and world through better understanding, improved predictions, clarity in communication, and the provision of tailored, actionable information to decision makers. There is a growing demand for high-quality and impactful weather and climate science as well as for the knowledge and applications generated from intersections with other fields. The rich department tradition of putting our science to work to help society gives us faith in a brighter future amidst challenging conditions.

Experiences over the past decade show how expanding populations, increasing urbanization and globalization, and a warming climate combine to create an increased societal and economic vulnerability to weather, particularly for weather and climate

extremes. Droughts, floods, tropical cyclones, winter storms, tornadoes, hail, and other forms of hazardous weather are increasingly frequent challenges to societal resilience. Anthropogenic climate warming is upon us, with harmful impacts ranging from increased wildfires to more favorable conditions for disease, yet concerted action to reduce net greenhouse gas emissions remains elusive and public discourse remains difficult. The effective use and communication of weather and climate information in the presence of varying levels of scientific confidence is challenging. Air quality also remains a significant health concern for millions of people across the globe, causing suffering and death, increasing health care costs, and negatively influencing economic growth. Yet we know that when society puts science into action, by using science to inform and communicate decisions in complex situations, lives, the economy, and ecosystem health can be improved.

New opportunities to improve prediction of the Earth system and our understanding of its predictability are facilitated through an explosive growth of observational and computational technologies and the data they generate. Advances in traditional and non-traditional observational capabilities, data assimilation, data analytics, artificial intelligence, numerical weather prediction, and ensemble forecasting have led to steady improvements in weather forecast skill and climate model utility over the past decades. Approaches to providing and effectively communicating reliable confidence information routinely are being used and refined. These improvements have dramatically changed how people and institutions respond to weather and climate predictions. The transportation, energy, agriculture, and public sectors take proactive measures when provided with high forecast confidence: airports, schools, towns, and industries routinely shut down or close early due to winter storms, hazardous weather, and hurricane forecasts; energy producers use weather forecasts to predict power demand and renewable energy production; and farmers use daily and seasonal forecasts to help make decisions regarding planting, irrigation, and pesticide application, with positive influences on sustainability. Governments, communities, and businesses are using climate predictions to help design for resiliency in energy and agricultural production, respond to the evolving needs of human and ecosystem health and social justice, decide on the sites and construction of infrastructure, and plan for a resilient water supply. As these examples illustrate, advances in our field have a direct positive impact on quality of life and the economy.

The continued potential for atmospheric and decision sciences to intersect and provide even greater value to society is only limited by our imagination and the number of trained personnel who have a solid understanding of the Earth system and an ability to solve problems. The Department of Meteorology and Atmospheric Science is well placed to advance our understanding and capabilities not only in atmospheric sciences but also in the interdisciplinary zone where weather and climate information is applied to solve problems and communicate actionable information in the private and public sectors, contributing to the wellbeing of society now and into the future.

In the context of society's increased vulnerability to weather, a warming climate, and with new opportunities to advance knowledge, educate students, solve problems, build community, and help to make a better world, six initiatives are defined within this strategic plan: (1) prepare students, staff, and faculty for life-long success; (2) drive digital innovation by empowering faculty and students to solve weather and climate risk problems; (3) drive digital innovation by advancing data assimilation and prediction skill; (4) steward our planet's resources by strengthening Penn State climate science; (5) transform education by enhancing faculty and student diversity; and (6) build the Penn State meteorology and atmospheric science brand: enhancing health, stewarding our planet's resources, advancing arts and humanities, and driving digital innovation.

Proposed Goals:

Goal 1: Prepare Students, Staff and Faculty for Life-Long Success

The Department of Meteorology and Atmospheric Science has a talented faculty with broad expertise that covers meteorology, atmospheric science, atmospheric chemistry, oceanography, climate, and space weather. The faculty provide undergraduate and graduate students with expertise in weather and climate processes and the use of weather and climate data to solve problems. The success of our undergraduates in finding suitable employment and entering graduate school highlights the strength of our program. However, in order to remain one of the best teaching and research programs, we can never be complacent. We need to ensure that we provide our students with high-quality advising and mentoring that helps them find and develop their skills, experience using the best tools and methods needed to solve problems, opportunities to hone their skills outside the classroom through real-world problem-solving experiences, programs that help them learn to communicate effectively to a wide variety of audiences, and professional development to assist them in their transition to the work force and plan their careers. We need to provide students outside of our department with a basic understanding of weather and climate and how to make practical use of this knowledge in their daily lives. We also need to support our staff and faculty in their career development and create a department where everyone feels like they belong. We already leverage our strength in e-Education to help commonwealth campus students prepare for their move to University Park, and offer courses in computer programming, data analytics, and communication.

Objective: Be a welcoming department for all

Action Items:

1. Reward faculty for high-quality student mentoring and advising, and for mentoring of junior faculty.
2. Continually assess and respond to student needs in math, physics, and scientific computing.
3. Provide synchronous remote teaching to commonwealth campus students for courses taken during the first two years; start with Meteo 273 and if successful then consider expanding to other courses as appropriate.
4. Encourage faculty and staff professional growth.
5. Develop greater adaptability in teaching approaches and methods, keeping in mind the needs of our students, and explore options for future course delivery.

Key Performance Indicators:

1. Mentor and advising activities in the annual faculty activity summaries, and regularly submit nominations for EMS and professional society advising and mentoring awards.
2. Annual assessments of students' math and physics skills.

3. Implement synchronous remote teaching of Meteo 273 for commonwealth campus students.
4. Number of professional growth activities provided each year for staff and faculty.

Objective: Proactively evolve curriculum to match societal and employer needs

Action Items:

1. Create a new undergraduate option in climate science.
2. Grow faculty expertise in weather and climate science and links to risk assessment and forecasting, human health, air quality, water, renewable energy, and planetary sciences through new hires or active collaborations with faculty in other departments and institutes while maintaining our core strengths in meteorology and atmospheric science.
3. Expand course content related to renewable energy, communication, statistical analysis, data analytics, and computer programming skills.
4. Integrate discussions of integrity, ethics, sustainability, and resilience into more of our courses.
5. Use alumni and industry partners to provide input on employer needs and curriculum, and to assist in student mentorship and course delivery.

Key Performance Indicators:

1. Status of climate science option for the undergraduate program, including any additional course proposals.
2. Percentage of faculty with active research being conducted in weather and climate risk, human health, air quality, water, renewable energy, and planetary sciences.
3. Percentage of courses that have content or enhanced content in these areas as indicated in the syllabi.
4. Percentage of courses that cover topics of integrity, ethics, sustainability, or resilience as indicated in their syllabi.
5. Number of alumni and industry partners actively involved in teaching and mentoring students and also advising the department. Number of alumni participating in the GEMS Mentoring Program.

Objective: Increase number of students who learn about weather and climate

Action Items:

1. Increase enrollments in our general education courses by offering residence courses online and by creating one or more new general education courses on climate.
2. Use more e-Education materials as course aides and improve our use of new technology and tools in the classroom.

3. Increase the number of students taking the online Certificate of Achievement in Weather Forecasting and the post-baccalaureate Certificate in Weather and Climate Analytics.

Key Performance Indicators:

1. Number of students enrolled in our general education courses.
2. Number of courses using improved tools and technology.
3. Number of students in the two online certificate programs.

Objective: Strengthen our graduate program

Action Items:

1. Elevate the importance of research tools and communication (written and oral) skills in addition to core knowledge.
2. Enhance our graduate student recruitment and mentoring.
3. Advocate for the creation of a college-wide under-represented graduate student group.
4. Vigorously aid students in applying for graduate fellowships.

Key Performance Indicators:

1. Percentage of graduate courses with content related to application of research tools or communication.
2. Increase in quality of mentorship as seen in yearly graduate student surveys.
3. Status of a college-wide under-represented graduate student group.
4. Number of graduate student fellowship applications submitted.

Goal 2: Drive Digital Innovation by Empowering Faculty and Students to Solve Weather and Climate Risk Problems

Weather and climate risk are defined broadly and range from personal decisions such as whether to leave work early to avoid an impending storm yet not be stranded on the roads, to company or government decisions on locating long-term infrastructure that minimizes impacts from climate change or improves air quality, and to even broader societal responses to global challenges such as climate change. Solutions to weather and climate risk apply to all decisions for which weather and climate information would help to solve a problem, assess an opportunity, minimize risk, or enhance social justice. Any discussion of risk must include the issues of integrity and ethics, as risk management is built upon an underlying set of values. Our undergraduate students in the weather risk management option have been highly successful after graduation, and a number of our recent graduate students also have found careers in this field owing to their training and expertise in big data, highlighting the continued need for this type of professional training in preparation for the careers of the future. For example, the world's response to anthropogenic warming requires a massive expansion of renewable energy, which is highly sensitive to weather and climate. Atmospheric scientists will be in high demand to facilitate this and other transformations demanded in response to climate change. Our faculty and students need the skills and understanding to work with engineers and economists to assist in societal energy transition and other forms of adaptation. This goal benefits from Department outreach and education efforts to communicate to students, industry, government, non-governmental organizations, and the public the ways in which weather and climate information is effectively communicated and informs decisions, promotes sustainability, and enhances social justice.

Objective: Grow our capabilities in risk assessment and societal impact

Action Items:

1. Evaluate and strengthen the undergraduate option in weather risk management.
2. Enroll more post-baccalaureate students in the online weather and climate analytics certificate program.
3. Leverage the expertise of the Weather Communications Group to assist in our outreach efforts on weather and climate risk.
4. Seek greater faculty participation in weather and climate risk research and teaching, where risk assessment encompasses natural hazards, air quality, human health, water and energy resources, urban systems, social sciences, economics, and seasonal to long-term climate change; the high degree of interdisciplinarity will require reaching out across the college and university to colleagues with complementary knowledge.

Key Performance Indicators:

1. Assess and report on status of the undergraduate option in weather risk management. If changes are suggested, then status of the suggested updates.
2. Number of students in the post-baccalaureate weather and climate analytics program.
3. Number of weather and climate risk media pieces on *Weather World* and in social media.
4. Number of faculty involved in teaching weather and climate risk courses; number of research efforts incorporating natural hazards, air quality, human health, water and energy resources, urban systems, social sciences, economics, and seasonal to long-term climate change; number of faculty collaborating with college and university colleagues on weather and climate risk teaching and research initiatives.

Goal 3: Drive Digital Innovation by Advancing Data Assimilation and Prediction Skill

Improvements to how we assimilate observations into numerical weather prediction models account for roughly a third of the improvements in weather forecast skill over the past decade. The use of ensembles for weather forecasting allows us to quantify the uncertainty or confidence of the resulting forecasts and has direct ties to the assessment of risk. It is not surprising that data assimilation and ensemble prediction are being used in a wide range of applications (e.g., global weather prediction, climate prediction, seasonal prediction, tropical cyclone prediction, thunderstorm prediction and analysis, planetary atmospheres, energy systems, ecosystem science, and carbon and water cycle science) and that several Department faculty members are leaders in data assimilation technique development. The Center for Advanced Data Assimilation and Predictability Techniques (ADAPT) was created in 2014 and already has an international reputation. ADAPT has enhanced Penn State's leadership in data analysis, assimilation, integration, and confidence quantification for both observations and model ensemble output. Continued support of the center will help the Department as it continues to grow synergies with other departments in the College, the Institute for Computational and Data Sciences (ICDS), the Huck Institute, and other Colleges at Penn State in the area of predictive sciences. The center provides numerous opportunities for student learning, particularly at the graduate level, with applications to solve real-world problems and brings many visiting scholars to Penn State.

Objective: Expand faculty and student collaborations in data assimilation

Action Items:

1. Continue to strongly support ADAPT and consider expertise in data assimilation for future hires.
2. Expand data assimilation and predictability content in course offerings, and mentor students whose research intersects the themes of ADAPT.
3. Add faculty partners to ADAPT from across disciplines at Penn State, and seek collaborative data assimilation/analytics projects with faculty in other departments and institutes, including ICDS and Huck.
4. Engage national laboratories and operational weather prediction centers as partners on data assimilation/analytics research.

Key Performance Indicators:

1. Number of faculty members involved with and contributing to the leadership of ADAPT.
2. Number of times a course that includes some aspect of data assimilation, predictability, and/or confidence quantification is offered. Number of students

engaged in data assimilation or predictability research. Number of seminars or other educational events with a data assimilation or predictability theme.

3. Number of faculty partners of ADAPT; number of disciplines represented by these faculty partners; number of active collaborative projects in data assimilation with faculty in other departments and institutes.
4. Number of funded grants in data assimilation; number of collaborative projects with national laboratories and NWP centers; number of papers written by center personnel; number of workshops/conferences hosted by or contributed to by faculty with a data assimilation theme.

Goal 4: Steward Our Planet's Resources by Strengthening Penn State Climate Science

Climate Science at Penn State University is a broad enterprise spanning multiple departments within the College of Earth and Mineral Sciences and multiple institutes and colleges across the University. Recognizing this landscape and that climate science has evolved beyond studying physical components of the climate system and their predictability, the Department has been a leader in building and strengthening climate science education, research, and communication across Penn State. With the importance of anthropogenic global warming to society, we must continue to increase these efforts and expand beyond basic climate science to integrate our teaching and research into climate impact assessment and mitigation programs. Achieving this goal is aligned with our teaching and research missions and will ensure that the College and University remain a hotbed of Climate Science research and education. We know that anthropogenic warming disproportionately affects the most unfortunate, negatively impacting social justice and increasing inequity, and this situation calls us to partner with social scientists, ethicists, and policy makers to understand and minimize these impacts. A dual-title PhD program in Climate Science was recently created that has its home in our Department and currently includes students in Geography and Anthropology. Our department also has hosted a summer Climate Science Research Experiences for Undergraduates (REU) Program since 2013 and has funding through 2024. These two efforts highlight that much climate-related research and education is based in our Department.

Objective: Become the nexus of climate science at Penn State

Action Item:

1. Identify and establish links to interdisciplinary research involving water, air quality, health, climate adaptation and mitigation, social justice, renewable energy, food security, and natural resources.
2. Support the creation of a Center for Earth System Modeling, Analysis, and Data (ESMAD) that is focused upon helping faculty across the university to select the best research methods, data, and models to study climate.
3. Encourage mentoring collaborations, including via the Climate Science dual-title Ph.D. and Climate Science REU programs, across departments, colleges, and institutes thereby building a community of Climate Science.

Key Performance Indicators:

1. Demonstrated funding for climate science with interdisciplinary links to other university research units.
2. Demonstrated success via availability of tools, data, and models for collaborative activities.

3. Number of interdisciplinary mentoring collaborations between our faculty and those in other departments, including those associated with the Climate Science dual-title and REU programs.

Objective: Grow both graduate and undergraduate education in Climate Science

Action items:

1. Increase the number of our graduate students in the dual-title program and encourage other departments to offer the dual-title to their students.
2. Explore enhancing the Climate Science dual-title to include an MS degree option.
3. Continue to support the Climate Science REU Program with administrative and technical staff support as well as encouragement of mentoring by faculty, post-doctoral associates, and graduate students.
4. Create a new undergraduate option in climate science (also in Goal 1).

Key Performance Indicators:

1. Increasing enrollment in the Climate Science dual-title graduate program.
2. Assessment of a Master's Degree option for the Climate Science dual-title program.
3. Number of department faculty, staff, postdoctoral associates, and graduate students participating the Climate Science REU program.
4. Status of climate science option for the undergraduate program, including any additional course proposals (also in Goal 1).

Objective: Increase outreach activities to broader audiences at Penn State and beyond

Action Items:

1. Increase climate content in our outreach and public education efforts.
2. Increase collaborations with faculty across Penn State on climate science research and communication by, for example, participating in Climate Crossover Week.
3. Increase course content on how to communicate climate information.
4. Develop and offer a summer Climate Camp to middle and high school students.

Key Performance Indicators:

1. Number of outreach and public education events.
2. Number of faculty collaborations on climate science research and communication.
3. Number of courses with climate science communication content.
4. Establishment of a summer Climate Camp.

Goal 5: Transform Education by Enhancing Faculty and Student Diversity

A key to achieving our goals of attracting a talented cohort of undergraduates and graduate students is to have a welcoming, inclusive environment and a diverse, supportive, student-centered faculty in which everyone feels a sense of belonging. One important element in creating this environment is to have the composition of the faculty mirror the desired composition of the students. Pennsylvania's population is 51% female and 49% male; 76% of the commonwealth's population is white, 12% is African American, 8% is Hispanic, and 4% is from other races. In contrast, 28% of our faculty are women and 12% are from under-represented groups while 35-40% of our students are women and 5-10% are from under-represented groups. Our faculty membership and student populations are slowly becoming more diverse and better represent the population of the commonwealth but more needs to be done.

Objective: Build a more diverse and inclusive community of scholars

Action Items:

1. Continue to aggressively recruit from the pool of women and under-represented faculty candidates, seeking cohort hires whenever possible, and conducting implicit bias training prior to every faculty search.
2. Seek partnerships with universities that serve historically underrepresented students in an effort to increase the pool of applicants to the graduate program.
3. Support the Supportive network for Women in Meteorology (SWIM), Penn State EnvironMentors, and Research Experience for Undergraduates programs, as well as other university and professional society diversity initiatives, such as the State College Chapter of Graduate Women in Science (GWIS), Summer Research Opportunities Program (SROP), Women in Science and Engineering Research (WISER), Minority Undergraduate Research Experience (MURE), UCAR Significant Opportunities in Atmospheric Research (SOARS), and AMS Colour of Weather and Coriolis events.
4. Actively nominate all qualified students for national fellowships, such as NSF and NASA.
5. Increase opportunities for students to learn about the diversity of scientific backgrounds that contribute to our field so that all students feel like they belong.

Key Performance Indicators:

1. Status of faculty diversity and implicit bias training.
2. Number and status of partnerships with minority serving institutions.
3. Number of faculty involved in EnvironMentors and REU programs and other university and professional society diversity initiatives.
4. Number of students nominated for fellowships and involvement in university and society diversity initiatives.
5. Number of social events that present the diversity of science backgrounds to our students.

Goal 6: Build the Penn State Meteorology and Atmospheric Science Brand: Enhancing Health, Stewarding Our Planet's Resources, Advancing Arts and Humanities, and Driving Digital Innovation

The Department of Meteorology and Atmospheric Science is internationally known for its meteorology and atmospheric science program, but it is much less well known for its programs in atmospheric physics, atmospheric chemistry, and climate science. Yet atmospheric physics, atmospheric chemistry, and climate science have been a central part of the Department for well over a decade. The science is clear that weather, atmospheric physics, atmospheric chemistry, and climate are all interrelated. Thus, we must continue to build our brand to emphasize the broad expertise that the Department faculty members bring to the University and to student learning. We are where weather and climate meet and we will continue to advocate for a breadth of faculty research expertise that is found nowhere else in the nation.

Objective: Grow the societal relevance of our research

Action Items:

1. Routinely engage our alumni in Department news and highlight the breadth of faculty expertise and student learning and success.
2. Seek to expand our faculty expertise in planetary sciences, space weather, weather and climate risk, renewable energy, economics, air quality, and health, while maintaining our current faculty breadth and increasing faculty diversity.
3. Enhance the Department's digital footprint, including the department electronic map wall and our web site, and use these resources to highlight our existing Department strengths.
4. Make effective use of social media to distribute our message by leveraging our efforts with similar initiatives across the College, Institutes (ICDS, EESI, IEE, Huck, Sustainability, Water Consortium, Energy Institute, Ecology Institute), and University.

Key Performance Indicators:

1. Number of department newsletters sent to our alumni every year, and number of alumni who assist in classroom or mentoring activities.
2. Number of faculty members actively involved in these areas of research as documented by active grants.
3. Documented improvements to the department's web presence.
4. Number of social media posts created by the department.
5. Fraction of our research budgets that support outreach efforts, such as NSF's broader impacts.